Wool Carding and Combing: With Notes On Sheep Breeding and Wool Growing

Aldred Farrer Barker

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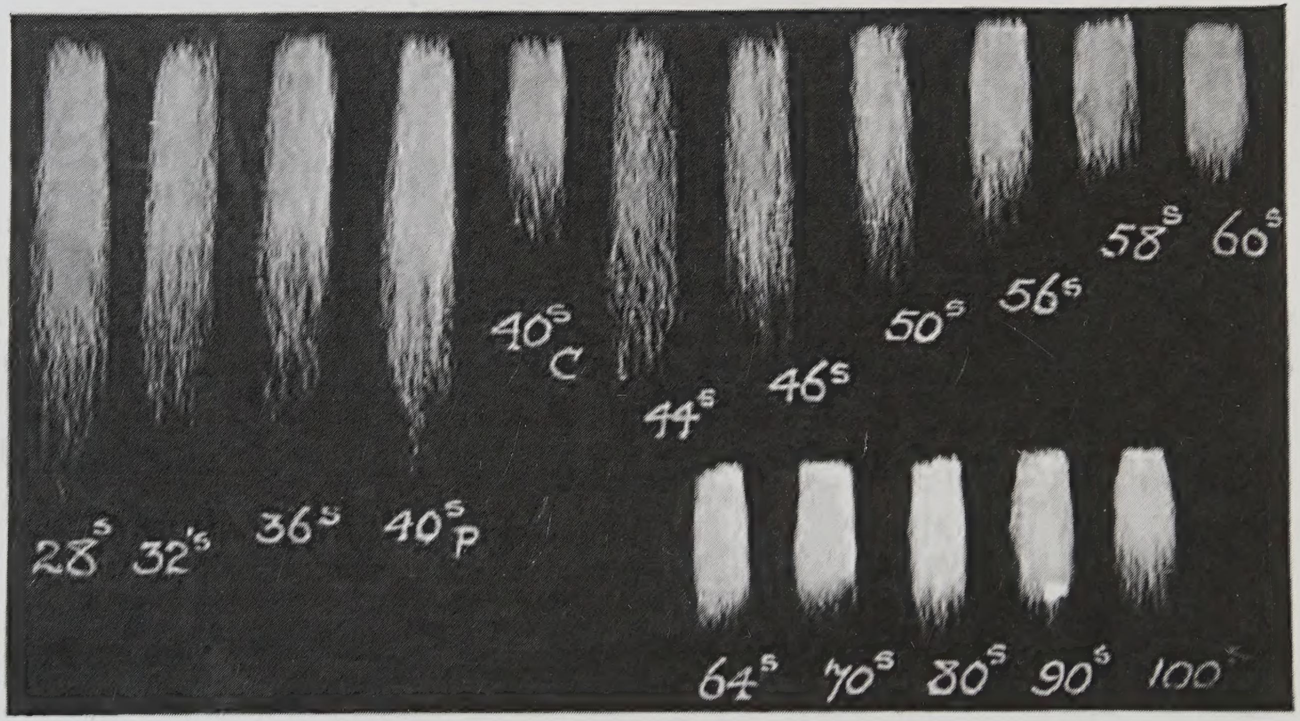

Bradford Tops: Range of Standard Qualities

WOOL CARDING AND COMBING

WITH NOTES ON SHEEP BREEDING AND WOOL GROWING

BY

ALDRED F. BARKER, M.Sc.

Professor of Textile Industries, Bradford Technical College

AND

E. PRIESTLEY

Ex-Lecturer in Combing and Spinning, Bradford Technical College

WITH 100 ILLUSTRATIONS

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PREFACE

Of the many books written on Wool Combing and Spinning, none has so completely held the field as W. S. Bright McLaren's "Woollen and Worsted Spinning." It appeared in 1884, and has been the basis of many text-books and practically all teaching up to quite recently.

Technical education, acting directly and indirectly, has resulted in a vast extension of the field of the technical and scientific knowledge appertaining to the Combing and Spinning industries, and McLaren's little work, good as it is, cannot now be considered other than inadequate.

After due consideration of all the points in question, the authors of the present treatise came to the conclusion that it would be necessary to so very materially extend the text for a new treatise, that it would be very desirable to publish such in two sections. They were further encouraged in this idea by reason of the demand for information on Wool, Wool Growing, and Wool Preparation from Australasians and others engaged in sheep farming, and also by the natural trade divisions observed in the industry, the wool comber taking wool up

to the "top" state, and then marketing it to the spinner. This volume therefore deals with this aspect of the subject and the early stages of the manufacture of wool, while a second, to follow shortly, will deal with spinning.

That this treatise is still in a sense inadequate, the writers are only too ready to admit. They hope, however, that it may at least serve as an efficient introduction to the very interesting sub-sections of the wool industry involved.

Their thanks are due to Professor T. B. Wood, of Cambridge University, for very kindly reading through the chapter on Mendelism; to Messrs. Wm. Cooper and Nephew, for illustrations of sheep; to Messrs. Dalgety and Co., and to the Bradford Chamber of Commerce for statistics which have been employed in this case as graphic illustrations; and to many others who have directly or indirectly assisted them in the production of the work.

A. F. B.
E. P.

January, 1912.

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WOOL CARDING AND COMBING

CHAPTER I

WOOL AND HAIR PRODUCING ANIMALS

The chief present-day wool and hair producing animals are the various breeds of sheep, the Angora goat, the Alpaca goat, the Cashmere goat, the camel, the cow, the horse, and the rabbit; while some few special wools or hairs are obtained in small quantities from such animals as the kangaroo, etc. Of these, the sheep holds by far the most important position with regard to numbers and quantity and quality of the fibre produced. The Angora goat, yielding mohair, and the Alpaca goat, yielding alpaca, come next in order of importance; while the camel, cow, horse, etc., yield but limited quantities of fibre suited only for very special purposes, camel-hair, for example, being largely employed for beltings, and rabbit-hair in hat manufacture.

Historical Sketch of Wool and Hair Producing Animals.—There are no records of the very early evolution of the sheep; but scriptural references are by no means uncommon. That flocks of sheep formed the chief possessions of the antediluvians there is abundant proof; and while our first parents, as Youatt suggests, ate as food the fruits of the earth rather

than the flesh of sheep, there are many evidences that their drink consisted of ewes' milk and their clothing of sheepskins. In addition to the information in the Old Testament that proves the largeness of the flocks of the early pastoralists,* the first real improvement effected on sheep by breeding is recorded.† Jacob, it appears, anxious to recompense himself to the fullest extent under the conditions so selfishly imposed by Laban, whom he had served fourteen long years for the sake of his daughter, resorted to the peeling of rings from the stakes forming the fold in order that the breeding ewes might be influenced to bring forth speckled instead of darkish brown lambs, which former were to constitute his wages according to Laban's promise.

Various improvements in breeding followed in course of time, the most marked resulting in the final dominance of whiteness, wool eventually being compared with snow.

In the absence of more definite records it is questionable whether the many types of sheep of the present day are the progeny of one common ancestor or have arisen independently. It is probable that in the remote past one type only existed, and that modifications of this type, due to varying environment and selection in breeding, have formed the basis of all our modern breeds of sheep. This evolution, in a broad way, may be represented in three stages through three types, each of which is still to be found under natural conditions.

1. The Argali (*Ovis Ammon*), of Asia and America.

* Gen. xiii. 6; Gen. xxxvi. 7; Num. xxxi. 32–3; Job i. 3; 1 Chron. v. 21; 2 Chron. vii. 5.
† Gen. xxx. 37, 38.

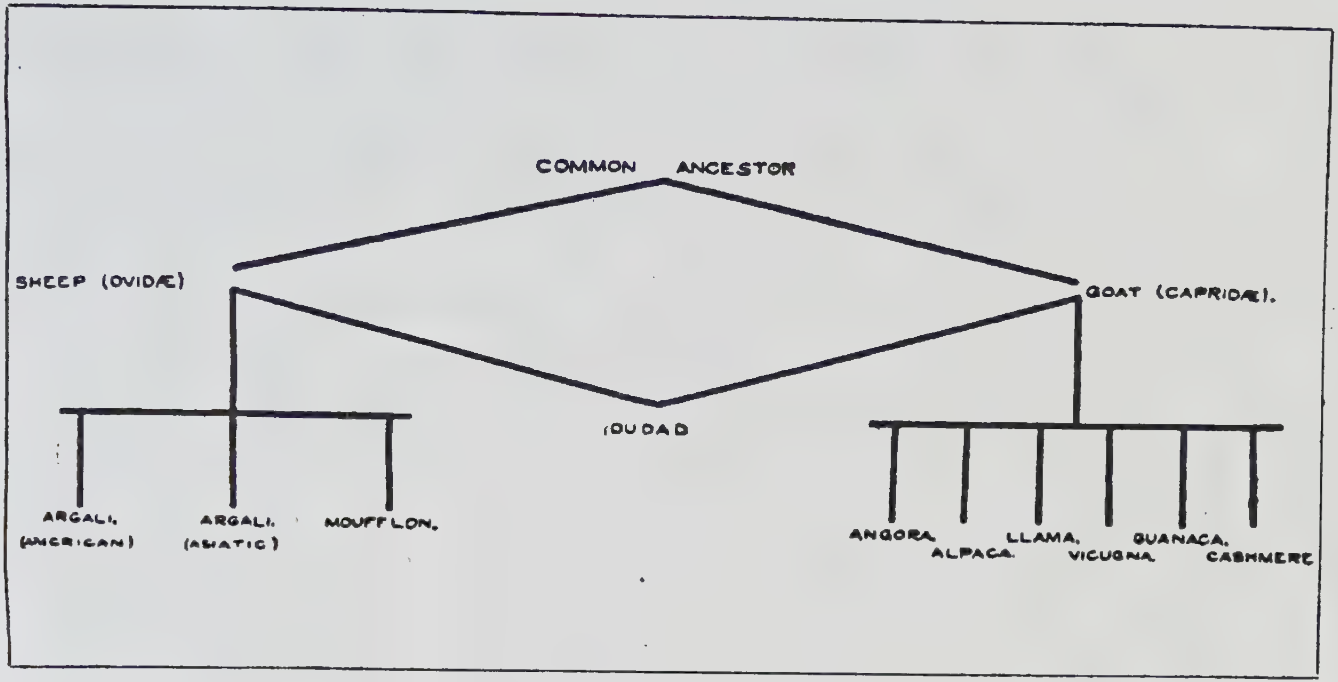


Fig. 1.—Diagram Illustrating the Evolution of the Early Sheep and Goat Tribes

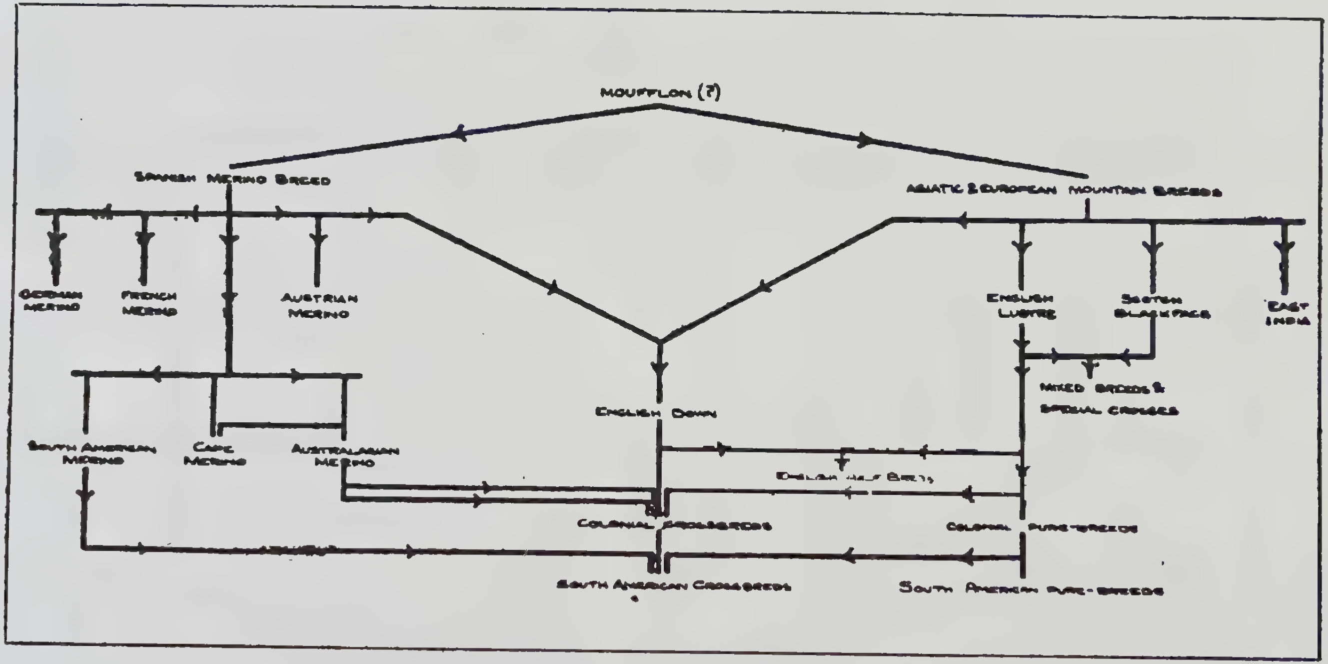


Fig. 2.—Pedigree of Present-Day Breeds of Sheep

2. The Moufflon (*Ovis Musmar*), of South Europe and North Africa.

3. The Domestic Sheep (*Ovis aries*), of Europe.

A few notes here on each of these types will not be out of place. Reference should also be made to Fig. 1 which gives a probable explanation of the way in which the broadly defined types have been evolved.

1. **The Argali.**—This animal still inhabits the higher plains and mountainous regions of Central Asia. It occupies the higher levels in summer; but descends to the lower plains and valleys, where food is more abundant, in the winter. The Argalis are animals of great beauty and strength, particularly the males, which are of large size, often 4 feet high at the shoulders, with horns well curved and of great thickness and length. The covering of these animals in summer is of a furry character and reddish-brown in colour. In winter distinct hair is developed of a brownish-grey character, with an under-coat of white wool. Domestication of the younger Argalis is possible, and this under suitable conditions brings about a permanent reduction of hair and an increase in the quantity of wool. In their wild state these animals congregate in small flocks and ordinarily show much fear of man.

Generally regarded as being related to the Asiatic type is the North American Argali, sometimes termed the Big Horn, Rocky Mountain, or Californian sheep. Save in size and strength—features in which it is superior—this is not unlike the Asiatic variety.

An animal closely related to the Argali and showing characteristics of both the sheep and goat is the Oudad, known also as the Bearded Argali. This animal is found principally in North Africa, is of uncommon appearance, very rough and ugly, with much

long hair of a reddish-brown colour growing on its front under parts.

2. **The Moufflon.**—This animal is found in Corsica and Sardinia and in such islands as Crete and Cyprus. In size it is smaller than the Argali, and its shorter horns turn inwards instead of outwards at the tips. Mountains not so cold as those occupied by the Argali form its native home, and these it seldom leaves. Like the Argali, it congregates in herds, but of greater number. The coat grown is of a short, brownish, furry nature, at the roots of which is a short, fine wool of a greyish colour. Domestication is said to have little effect upon this animal, the type appearing to be less subject to the influence of domestication than the Argali.

3. **The Domestic Sheep.**—While there is no definite history to prove that the various domestic breeds have originated from such animals as the Argali and Moufflon, in some such way as is explained in Fig. 2, it is by no means difficult to imagine that such may have been the case. The early use of the skins of animals slaughtered in the chase would gradually evolve the idea of greater comfort in clothing. Observations upon the effects of climate and physical surroundings would be made at an early period. Thus it would be observed that the change from the summer to the winter season would cause an increase in the wool or down (which is necessary for greater warmth) and in the hair (which forms protection for the wool), and this might conceivably lead to definite experiments in breeding definite types of wool or hair producing animals. Once this idea took root, it can well be imagined how environment and selective breeding would be employed to evolve from the rough, uncouth animals previously referred to the much more valu-

able domestic sheep. It has been suggested that the nomadic races crossing the plains of Central Europe, and eventually arriving in Great Britain, brought with them the partially or fully developed sheep, and, finding suitable conditions prevailing in these islands, soon made their breeds world renowned. More definite particulars are on record of how Southern European civilisation—especially during the dominance of the Romans and the Moors—evolved the Merino sheep of Spain, from which all the fine-woolled Merino sheep of to-day directly or indirectly are derived. The differences between the various present-day breeds of sheep are most marked. Compare, for instance, the Australian Merino and the Border-Leicester breeds—and support of the idea of an evolution such as that suggested is obtained, notwithstanding the fact that representatives of the intermediary stages are not now to be found.

Angora and Cashmere goats have obviously been subjected to far less artificial improvement than the sheep, and the same remark applies to the camel and the various representatives of the camel race in South America, such as the Alpaca, Llama, and the Vicuna.

Natural History of Wool and Hair Producing Animals.—The chief wool and hair producing animals belong to the natural Order *Ruminantia* (cud-chewers), and constitute the fifth family, *Bovidæ* (Latin *Bos*, meaning ox). Of this family there are :—

(*a*) **Sheep of the Genus *Ovis*.**—A grazier (grass eater) as distinct from the goat, which is a browser (shrub-eater). Some types of sheep are horned, and some are hornless. The skin or pelt is comparatively thin, and on it is produced in the case of animals in the wild state a mixture of hair and wool. As the varieties

are so numerous and marked, special treatment is given to each later on in this volume.

(*b*) **Goat of the Genus *Capra*.**—This is an animal lighter in build than the sheep, very quick and sure-footed, and a browser. Many types are horned, and the male is frequently bearded. The fleece is heavy, and consists of hair with an undergrowth, in many types of a fine fibre of a woolly character. Environment seems to have little effect on the hair produced, so that breeding is the dominant feature in obtaining the quality of hair required. The following are varieties that claim special attention :—

(*b*1) **The Angora Goat** (Fig. 3).—A species descended from the animal *Capra Ægagrus*, the claimed ancestor of all *Capra Hircus* or domestic goats, inhabiting the hills and mountains of Southern Europe and Asia Minor. It is fairly large in size, and possesses horns of considerable dimensions. It grows a short, woolly fur of a greyish-brown colour during the warm season, and this, in winter, is covered with a larger and brighter hair. History is silent as to its early domestication ; but the goat doubtless existed in very remote times in the province of Asia Minor, where under suitable climatic and physical conditions it has for ages produced hair of remarkable length, lustre, and fineness.

(*b*2) **The Alpaca.**—Of the llama group (Fig. 4), a species somewhat allied to the camel (*Camelus*) family, this relationship being noticeable in the neck formation and in the carriage of the animal. This goat is indigenous to the lofty Andes in South America, and has never been successfully acclimatised elsewhere. It is the most important member of this group, the other members being the llama, the vicuna, and the guanaco, some of which are met with in both the wild and domes-

Fig. 3.—Angora Goat

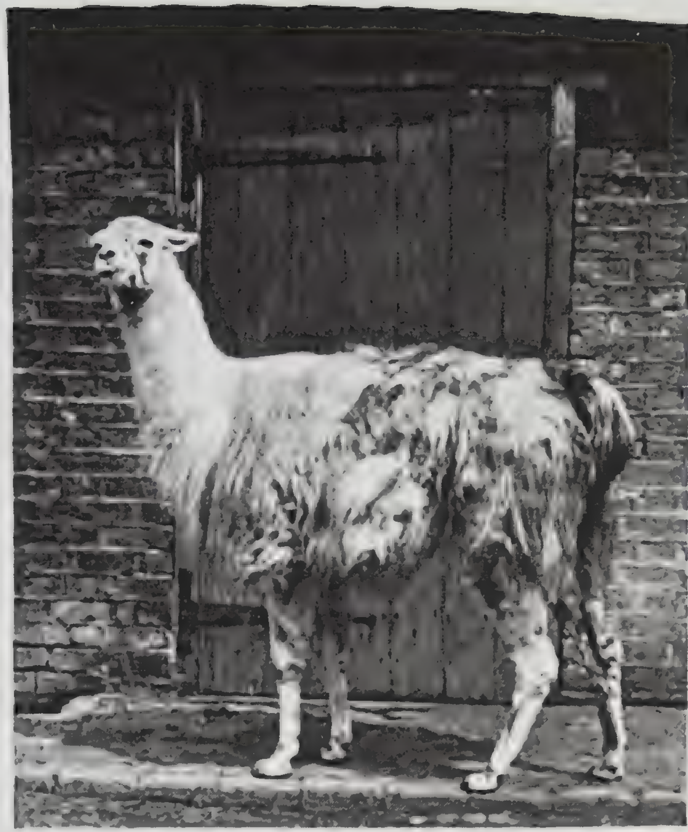


Fig. 4.—Llama

ticated states. Its covering resembles both wool and hair, being chiefly brown and black in colour, but occasionally fawn and white. It is interesting to note that as distinct from most sheep it will carry its fleece from two to three years, in which circumstances the staples attain a length of thirty inches and upwards.

Special note should be made of the short, fine, brownish-yellow fibre obtained from the vicuna, a wild animal of the group which exists in but small numbers in Peru.

(*b*3) **The Cashmere Goat.**—An animal closely allied to the native Tibetan goat which inhabits the district of Cashmere (or Kashmir) in northern India. It is provided with enormous horns, and is covered with a coat of long, straight, and silky fibre, at the roots of which, on certain portions of the body, is to be found a small quantity of very fine wool of a brownish colour. This latter—the true cashmere of commerce—is the material from which are made the renowned Cashmere shawls—of which the Paisley shawl is a derivative—noted for their softness of handle, fineness in texture, and beauty in design and colouring. As with the alpaca, attempts at acclimatisation of the Cashmere goat in countries other than Cashmere have met with no lasting success. Possibly this localisation of the breed may also be due, as was the case at one time with the Angora goat, to the unwillingness of the present owners of flocks to promote their introduction elsewhere.

(*c*) **The Camel.**—Of the true camel species there are two types—the Asiatic bactrian and the African dromedary, the former possessing one hump and the latter two. On the under portion of the body of the camel is found a quantity of rough, long, bristly hair, and underneath this a shorter woolly material. As the fibre is essentially a by-product, no attempts are made

in any case to cultivate it. It comes chiefly from China, Russia, and Egypt.

(*d*) **Cattle.**—Home, colonial, and foreign breeds are of value as yielding fibre useful to the textile industries, although, as with the camel, this fibre must be considered relatively a by-product. Cow-hair, taken from the skins of slaughtered animals, is employed for the manufacture of cheap carriage rugs, plushes, low woollens, stuffings, etc.

(*e*) **The Horse.**—The horse yields hair of two types. The body hair is employed similarly to cow-hair, but the longer is woven by specially built looms into upholsteries of a very durable type.

(*f*) **The Rabbit.**—This hair, or fur, since the introduction of the rabbit into Australasia, now comes to us in great quantities. It is remarkable for its softness and fineness, and is largely used in the felt-hat industry, and, to a limited extent, in the woollen trade.

The other fibre-producing animals scarcely call for comment; but it seems rather strange that neither the sheep nor the goat has a rival in the same sense that ramie has been the rival of linen and cotton for, say, fifty years.

The Sheep of Great Britain.—The historical records of this country tend to show that the evolution of the wool industry followed the sequence which would naturally be expected. From the employment of the skins of sheep as clothing and as a covering in small sailing-boats in pre-Roman Britain, the evolution led up to the woollen factory at Winchester in Roman times, and from there through many vicissitudes of fortune the wool industry has been steadily evolved to its present-day efficiency. It seems possible that a fine down wool, possibly grown then as now, in

HAIR: MOHAIR ALPACA CASHMERE & CAMELS HAIR.

locks

the south of England, was the staple product worked with, as one Roman historian speaks of wool "often spun so fine as to be comparable to the spider's thread." This, however, was probably only a figure of speech; for when, centuries later, the wools of Britain came into competition with the wools of Spain, they were recorded as coarse, harsh, and uncouth in comparison. After many vicissitudes, the wool trade, encouraged in various ways by the rulers of our land (King Alfred, for example), who, no doubt, found it a valuable source of revenue, attained to considerable importance, and increasing quantities of wool were exported to Flanders to be manufactured and often returned to this country in the form of cloth. This led to endeavours to improve the manufacturing skill of our people, and legislation under several monarchs was undertaken with this end in view. Success finally attended these efforts, so that not only did England manufacture her own wool, but actually brought wool over from the Continent, and finally from Australasia, to be spun and manufactured into cloth. In part owing to the demand for a large carcass sheep, and in part owing to natural tendencies, the typical English sheep was finally evolved as a large sheep, producing long, lustrous wool, specially suited for spinning into "worsted" yarn. A finer-woolled sheep still flourishes upon "the Downs," and in other parts of the country, but this cannot compare in fineness with the wools of Australia; while, on the other hand, no country at present produces such beautiful long lustre wools as England.

In recent times fluctuations in the price of corn have markedly affected the proportion of land under ploughing, and consequently, indirectly, the number of sheep reared (Fig. 6). Upon the whole, however, sheep have always held their own—perhaps because

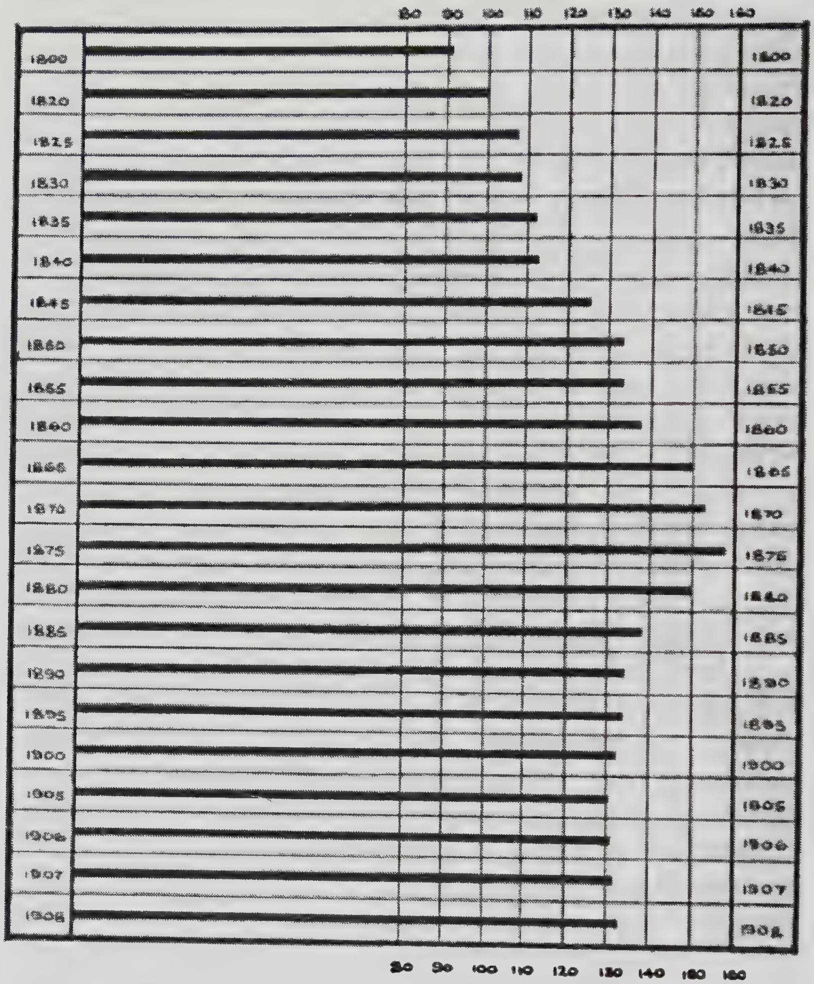


Fig. 6.—Production of British Wool (in millions of lbs.), 1800-1908

corn and foodstuffs are more easily transported than sheep—and under the hands of skilful breeders both the sheep and the wool have been moulded to give the best return as a whole under the varying climatic and soil conditions of this country. Fig. 7* illustrates graphically the most recent returns of the number of sheep in Great Britain, and, indirectly, gives an idea, in conjunction with the particulars which follow, of the proportions of long and short wool grown.

The most convenient trade classification of the breeds of British sheep is as follows :—

1. **Long Wool Breeds.**—Lincoln, Leicester, Border-Leicester, Cotswold, Romney Marsh, Wensleydale, Devon.
2. **Short Wool Breeds.** — Southdown, Shropshire-down, Hampshire-down, Oxford-down, Suffolk-down, Dorset, Ryeland.
3. **Mountain Breeds.**—Blackface, Herdwick, Cheviot, Lonk, Dartmoor, Exmoor, Penistone.
4. **Highland Breeds.**—Short-tailed sheep, Welsh, Irish.

The first class consists of a type of large and well-proportioned sheep, severally occupying the heavy agricultural lands of England, and which yield wool of a long, strong, and lustrous type. Formerly these were reared in the midland and western counties only, but latterly they have been distributed over a much wider area. Much attention has been given to these breeds, with very satisfactory results both as regards wool and mutton. Cross-breeding has been extensively employed to produce distinctive features, so much so that it is now a matter of much speculation to locate the ancestral type.

* From the tables published by the Bradford Chamber of Commerce.

The second class is represented by the oldest breeds of England—these being known to many as the ancient upland breeds—the various classes being depastured over the eastern, southern, and western portions of this country, including the Down range of chalky hills, long celebrated as the home of high-class breeds of sheep. In form this class was originally much smaller than the aforementioned type, and from the standpoint of quantity, either of wool or mutton, the breeds were not so valuable, but they occupied lands which to other sheep would have been less serviceable, and yielded a fine, white, and crisp handling wool of great value to the textile industry. To-day the Down breeds are by no means small in size, and are specially valuable as mutton breeds on account of their very early maturity.

The third class, as might naturally be expected, are of a poorer type; they are spread over the hills and moorlands of the country, are largely neglected, and consequently development of either form or covering is seldom favoured. The breeds, however, have their value; without them much land would be sheepless and unoccupied; and, moreover, the range of qualities and the variety of prices of fabric, so necessary to trade requirements, would be disadvantageously less if these breeds were absent.

Included in the fourth class are the wilder and more badly bred types which occupy the more outlying parts of the kingdom. With an environment so severe as in these remote districts, and with the scant attention they receive, it is small wonder that many of the types are still in the primitive condition—goat-like in character and yielding a light and uneven fleece of wool and hair that often varies very considerably in colour, even in individual sheep. In some few cases, however,

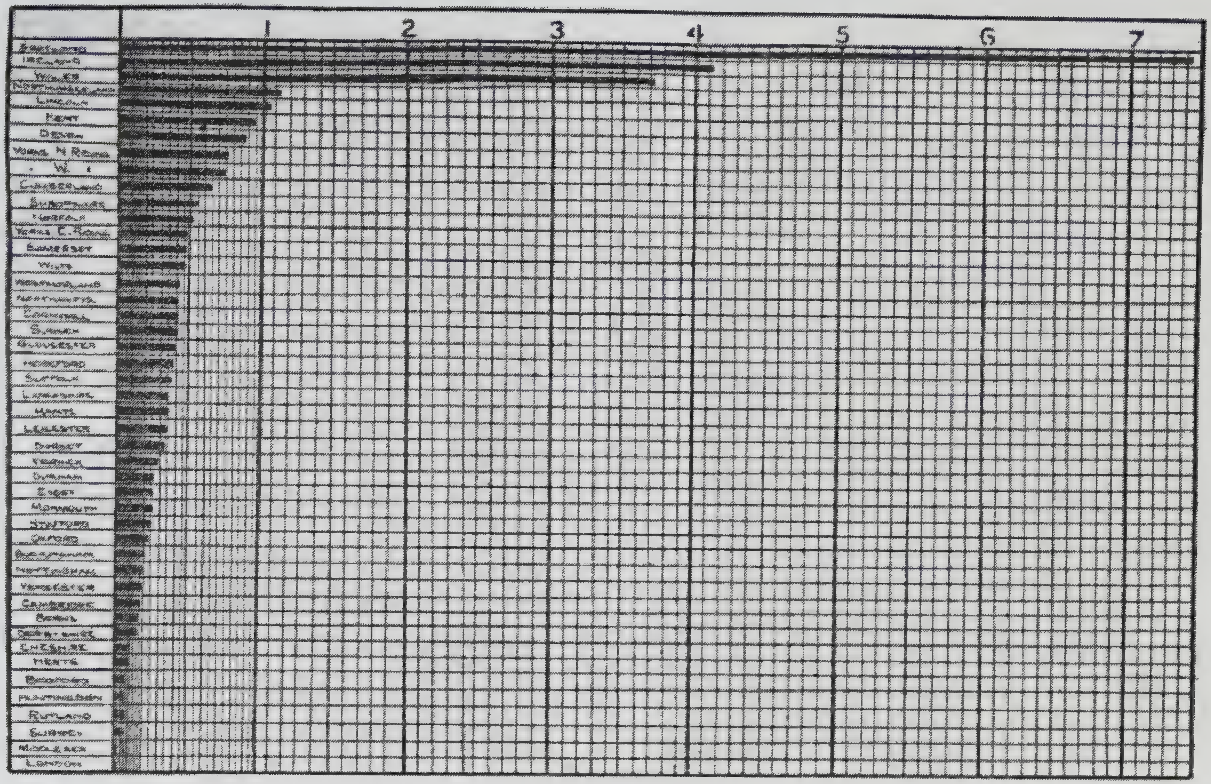


Fig. 7.—Number (millions) of Sheep in Great Britain, 1909

special wool is produced, as, for example, Shetland wool, which is of a very soft handle

Class I.—**Long Wool Breeds.—The Lincoln.**—Reverting to Class I.—the long-wool breeds—the Lincoln (Fig. 8) is placed at the head. It is the progeny of an old Lincoln breed now almost lost sight of, which was crossed on an improved Leicester breed in order to produce greater symmetry of form or a greater propensity to fatten. No type of sheep is more massive and heavy than this or yields a longer and bigger fleece. The breed requires pasture of rich and abundant growth. Should it be stinted, it quickly loses condition, which it does not readily recover. In addition to being used either purely or as a cross in almost all English long-wool counties, it has found extensive employment in Australasia and South America, chiefly for crossing purposes.

Leicester (Fig. 9).—This is perhaps England's choicest long-wool breed. It doubtless represents the greatest application of scientific treatment. This is the breed on which the renowned Robert Bakewell of Dishley expended so much thought and care, and the breed which, while possessing all the good qualities of the Lincoln, such as size and hardihood of constitution, as well as those pertaining to the wool, is additionally valuable in that it is finer and more lustrous in staple and choicer in the quality of mutton. It has been widely used with other breeds, in all cases with much success; and no breed, it is stated, is more pronounced in the dominance it impresses of its own type upon its progeny. As a cross on the Merino it is specially serviceable, both as regards wool and mutton.

Border-Leicester.—This breed—a cross between the new Leicester and the Cheviot—proves the value of the former as a crossing breed; for on the Cheviot

Fig. 8.—Lincoln Two-Shear Ram (about half wool growth)

(Photograph by permission of Messrs. William Cooper and Nephews, Berkhamsted)

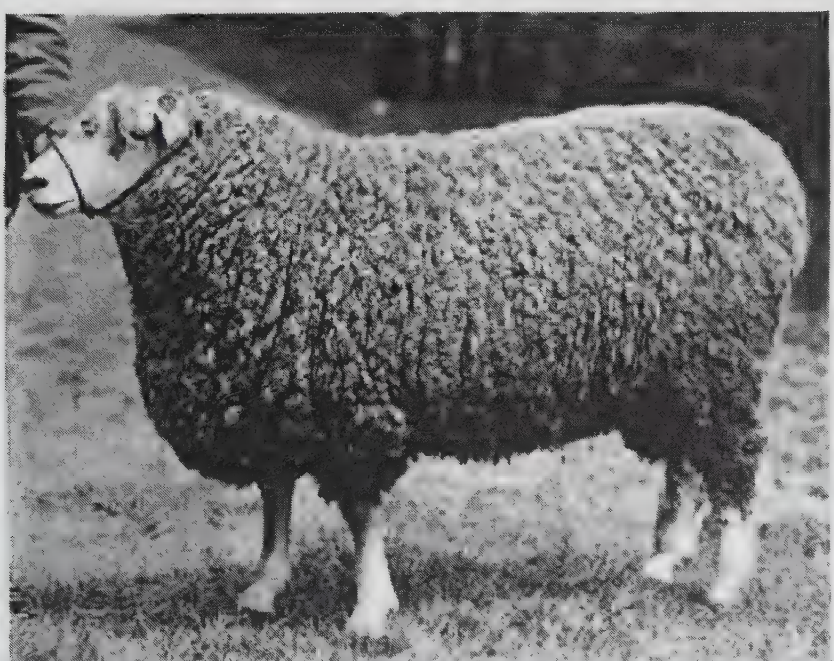


Fig. 9.—Leicester Sheep

sheep—a native of the hills running through the borders of England and Scotland, from which it takes its name—it was used for the purpose of improving the carcass so successfully that the resulting type became quickly acknowledged as a standard breed. Over a very wide area in the south of Scotland this type finds considerable favour, as it also does in the Colonies. A cross from the Border-Leicester and Cheviot produces the wool known in bulk as "North."

Cotswold.—In appearance this is one of the prettiest of all English breeds. It inhabits the hills in Gloucestershire and neighbouring counties which bear its name and which have long been its home. For withstanding hardship this breed is extremely serviceable; and as, further, it is remarkably prolific, it finds extensive employment, both as a mutton and wool producer. It is very satisfactory as a cross and formerly, more than at present, was extensively used on the finer breeds.

Romney Marsh (Fig. 10).—Of all breeds this is most suitable for marshy and boggy districts. From time immemorial it has been pastured on the bleak, low-lying marshland on the south coast of Kent, and has there developed qualities of constitution which have created it quite a distinct breed. No type can so successfully withstand foot-rot and fluke, and for much land in all countries of pastoral usefulness where the conditions favouring these diseases obtain, it is of the greatest service. It is not so symmetrical as the types previously referred to, though through an infusion of Leicester blood it is greatly improved; nevertheless, it is of useful size and of good quality in both mutton and wool, the latter being medium in fineness and demi-lustrous, and known in the trade as "Kent Hogs" or "Kent Wethers."

Wensleydale.—This breed is probably less famous than most of those already mentioned. It is of chief interest to the Yorkshire Dales farmer, though it is very common in Durham and in some parts of Scotland. It originated in the Tees Valley, the border line between Yorkshire and Durham, and was formerly ungainly and poor in fleece; but through the influence of the Leicester crossed upon it a change has been effected of a very useful character. It is hardy in constitution, thrives well on somewhat rough pasture, and yields good mutton and a good quality lustre wool. There are two types of which the "blue-faced" is the dominant breed.

Devon.—In Cornwall, Devon, Somersetshire, and the southern part of Hampshire a breed is found known as the Devon long-wool. The origin of this breed is the Bampton Nott (Bampton, a village on the borders of Devon and Somerset) and the Southam Nott, both of which have been greatly improved by crossing on the new Leicester. The latter variety is somewhat smaller.

A recognised Devonshire Southam breed, with physical characteristics somewhat resembling the Romney Marsh and Shropshire wool, and similar to the long lustre type, is found in South Devon, on the borders of Dartmoor and Cornwall. This breed contains much Leicester blood. It is only on the rich pastureland, however, that this sheep is to be found.

Class II.—**Short Wool Breeds.—The Southdown.**—The Southdown is typical of the short-wool breeds, and on account of the fineness, whiteness, and shortness of its wool might be termed the English Merino. This is an old English breed which has been the object of unremitting attention for a consider-

Fig. 10.—Romney Marsh Sheep

Fig. 11.—Oxford Down Sheep

able period, and no other breed in this country has attained to such a standard of both mutton and wool. Its home is the Downs of England, but its adoption has extended far and wide, not only in Britain, but in the Colonies, the United States, and South America. As a Merino cross for mutton it cannot be surpassed. The wool, however, judged by the usual Merino cross standard, lacks character and is somewhat light and wasty.

Shropshire Down.—This breed (Fig. 12) is somewhat larger than the Southdown, and also hardier and more thrifty. Most likely this has been developed from an old "Morfe Common" sheep—named after the land in Shropshire on which they were reared—by the introduction of the Southdown and also the Leicester and the Cotswold long-wool types. From all standpoints it is highly satisfactory as a breed, and is most extensively reared both at home and abroad. As a cross on the Merino type it is especially serviceable.

Hampshire Down.—The Hampshire is larger than the Shropshire, but yields wool of the Southdown order. It is probably a development of the old Down-like breeds of Wiltshire and Berkshire, into which counties the Hampshire has extended, as aided by the Southdown. This breed well illustrates the power of the breed influence, for it possesses many distinct properties, all of which go to make an excellent type. As a Merino cross, though very suitable, it has not as yet attained the popularity of which it is worthy.

Oxford Down (Fig. 11).—This was produced by crossing Cotswold rams upon the ewes of an old Norfolk breed. It is a comparatively new type. In appearance this sheep is striking, being large and rounded off, while for mutton purposes it is very serviceable. The wool is bright and fine and is of fair length, but rather

open and wasty. It is not so good in colour as the Hampshire Down.

Suffolk Down (Fig. 13).—This is one of the prettiest sheep bred, being hornless and possessing a bright, clear, shiny black face. It is not large in body, and its wool is perhaps hardly equal to the fine Southdown wool.

Dorset (Fig. 14).—This very old breed—grown principally in the western portion of the county whose name it bears—is somewhat larger than the Southdown, is horned, and yields wool of a longer and plainer character. Its great value is for mutton, for there is no breed more prolific or more successful in the rearing of its lambs. This breed supplies the bulk of the Christmas lamb to the London markets. Being strong, hardy, and active, and a quick fattener, it is now commanding considerable attention from the farmers, who, on account of the difficulty in growing wool so profitably as formerly, are in addition seeking to develop the mutton. As a cross it does well, being largely used on the Shropshire in this country and on the Merino in the colonies. A variety of this breed, though yielding coarse wool, is grown on the Falkland Islands, and another in Somersetshire, the fleece of the latter being more of a lustre quality.

Ryeland.—The Ryeland, named after lands on which rye is produced, has long been grown in Herefordshire; but it is now found in Shropshire, Monmouthshire, Gloucestershire, and Warwickshire under various names locally obtained. It is of small build and grows wool of remarkable fineness, which before the days of colonial Merino was much valued. This sheep has now ceased to be profitable, owing to the smallness of the carcass and the lightness of the fleece. Crossed on the Lustre breeds, it has been fairly serviceable, but little appears to have been done with it in relationship to the Merino.

Fig. 12.—Shropshire Down Sheep

Fig. 13.—Suffolk Down Sheep

Fig. 14.—Dorset Sheep

Class III.—**Mountain Breeds.**—Scotch Blackface (Fig. 15).—This is of quite a distinctive type. It is found on the Scottish hills and the elevated and unsheltered places in the English counties of Cumberland, Westmorland, Lancashire, and Yorkshire. In its pure or crossed state it forms the basis of the flocks owned by the Yorkshire moorland farmers. Usually the mutton is of fair weight and quality; but the wool is poor, being long, thick in fibre, and well intermixed with kemps, and light in weight of fleece. Generally it does not cross well, though distinct improvement has been wrought in it by carefully selected types of the Cheviot, Lustre, and Down varieties.

Herdwick.—Occupying the hills and mountains of Cumberland and Westmorland, this breed is remarkable for its hardiness and thrift. Like the Blackface, it provides useful mutton, but it is of slow growth, and the wool is of no particular value.

Cheviot.—The Cheviot is one of the most useful breeds extant. Grown on the Cheviot Hills running from Northumberland into Scotland, it is well suited to rough conditions, save those which are most extreme. This breed is very satisfactory as mutton, and it also supplies wool of a fine, dense, and white character, which is much valued. For its native locality crossing on it has been proved unsuitable, having weakened it constitutionally; but as a cross on other breeds to effect useful modifications it has been largely employed, particularly on the longer types. The two most remarkable of these are Leicester cross Cheviots and "North" or Border-Leicester cross Cheviots.

Lonk.—This, the product of the Cheviot crossed on the Blackface, is now an established breed, inhabiting principally the hills of Yorkshire and neighbouring counties. Considering the environment in which it

lives, the return given is exceptionally good, the carcass being large and the mutton palatable, while a heavy fleece of fairly fine and soft-handling wool is produced.

Dartmoor.—Fulfilling similar requirements to the foregoing breeds is the Dartmoor, named after the moorlands it inhabits in Cornwall and Devon. Though small, the mutton is excellent; the wool, however, is short and somewhat coarse and light in weight. Crossing the Leicester on this breed is said to have improved it considerably.

Exmoor.—These sheep are very small, but in other features they are similar to the Dartmoor, both showing certain relationship to the Dorset breed. They are known also as "forest breeds."

Penistone.—For long ages this breed has existed in the West Riding of Yorkshire and on the Lancashire Border. It is extremely rough-looking, both in form and in the character of the wool produced; and it possesses a long and bony tail, which gives it a somewhat remarkable appearance.

Class IV.—**Highland Breeds.**—In the Orkney and Shetland Islands, and also the Hebrides, a wild race of animals, distinguished by a short tail, is found, exceeding in constitution almost all other breeds. The type somewhat resembles the goat. The fleece, which is very light, consists of wool and hair; and if the former is not shorn it will separate on its own account during the summer. No shearing as a rule is undertaken, but the wool is "roo-ed"—i.e. plucked by the hand. Improvement has been attempted by crossing, but only with the Cheviot has that quality of endurance been retained which is essential. As improvement in communication increases it is likely that the introduction of more profitable breeds will supplant the present type.

Fig. 15.—Scotch Black-face Ram

Fig. 16.—Welsh Mountain Ram

(Photographs by permission of Messrs. William Cooper and Nephews, Berkhamsted.)

Welsh (Fig. 16).—Generally two breeds prevail which are native to Wales, the first of which occupies the high mountains in the southern districts. It is not large, but of a wild and active order, yielding a fleece vari-coloured and of small weight. As mutton it is good. A characteristic of the breed, even in its improved type, is that of black hair, which covers the face and legs. A second breed—and the most important one—is known as the soft-woolled breed, this yielding excellent mutton and white wool (with which is mixed a proportion of hair), from which the celebrated Welsh flannels are made. This is a small, agile sheep, and, like the first-mentioned type, ordinarily inhabits the higher altitudes.

A Welsh breed of some trade importance is the Radnor, which is probably a development of the Welsh mountain sheep through the introduction of the Shropshire and other Down breeds. An old Radnor still exists which in fleece resembles the soft-woolled Welsh type; it is of a size similar to the mountain sheep.

Irish.—As is the case with Welsh sheep, two distinct varieties of sheep exist in Ireland—those of the mountain and those of the vale. Of the former breeds the chief are the Wicklow, which inhabit the mountains of that name on the east coast, and the Kerry, which are found chiefly in the western districts. They are similar to the Welsh soft-woolled type, those occupying the higher districts, however, showing much intermixture of hair. Crossing on the Southdown is carried on in many districts with successful results, both in wool and mutton, though there are evidences that the constitution is weakened through this procedure. The Kerry is distinctly larger than the aforementioned, and is somewhat ungainly. The mutton is excellent, but

the breed is lacking in good wool characteristics and, further, is slow of development.

The vale sheep are of the long-woolled variety and are, of course, larger. Crossing has been effected with improved English breeds, largely of the Leicester type, with very satisfactory results, particularly in character and weight of fleece.

In Fig. 17 a general idea of the distribution of the various breeds in the British Islands is given.

Colonial and Foreign Breeds.—From ancient records it would appear that the Greeks, the Romans, and the Moors followed one another in conserving and developing the fine-woolled sheep from which all the Merino breeds of the world are derived. The evolution of the Merino sheep seems to have taken place along the shores of the Mediterranean, ultimately attaining its perfection in Spain.

Spanish Merino.—The home of the Merino is Spain —a country long celebrated for its wool, to which most of the important wool-growing countries of to-day are indebted for the new blood which has effected such marvellous improvement in their flocks. In Spain three types of sheep exist—the Chunah, a large, long-woolled sheep kept in small flocks by the Spanish peasants, yielding a fleece fulfilling local requirements; the stationary Merinoes—termed stationary, or *estantes*, along with the Chunah, because they remain on the same pastures; and the migratory Merino or *trans-humantes*, which change pasturage with the various seasons. It is the latter which is the important breed, being the one from which the great colonial flocks are descended. In developing the Merino sheep, everything has been subordinated to fineness of character in wool; possibly as a consequence of this the form

The DISTRIBUTION of BRITISH BREEDS of SHEEP.
O = Numbers of Sheep in thousands.
SCOTLAND
BLACK FACE, CHEVIOT & BORDER LEICESTERS
IRELAND
MOUNTAIN & MIXED BREEDS
Blackface & Lonk
DOWNS & DOWN CROSSES
Welsh Mountain
Shropshire & Downs
Leicester
Lincoln
Southdowns
Suffolk Downs
Romney or Kent MEDIUM
MOUNTAIN BREEDS DEVON LONG WOOL
Devon Southdown
Southdown
South Downs

Fig. 17

of the sheep is inferior to that of other types. For long ages this sheep was closely guarded by the Spaniards, its exportation being punishable by death. But in 1723 Sweden imported a small number, with, however, no very great success. France followed, failing altogether, though fifty years afterwards, under Government auspices, Spanish sheep were again introduced from which a celebrated Rambouillet breed was developed. Then Germany made the attempt, proving, with its importation to Saxony in 1765, very successful. Into Austria in 1775 a flock different from the Saxonian type was taken, which prospered remarkably. The breed in Saxony is known as "Escurial," as distinct from the term "Infantando" or "Negrette," applied to the Austrian type. An introduction of Spanish Negrettes took place into England in 1787 and 1791 at the instigation of George III., and although from various causes the venture was not a success as regards the development of the Merino, much improvement was effected in the Down and even in the long-woolled types by crossing the Merino upon these.

Australasian Breeds.—It is in Australia and New Zealand—both as a pure breed and a cross—that the Merino has achieved its greatest success.

Introduction to New South Wales.—The Merino was first introduced into New South Wales as already mentioned. From New South Wales the breed spread in a westerly and southerly direction and reached Tasmania and New Zealand, and as the colonies were developed, it became the foundation of a gigantic colonial industry and the basis also of the great woollen and worsted trades of the world. Sheep-farming is now a science. Endeavours are being made to understand the influence on sheep of the prevailing condi-

tions, and careful experiments have been and are being made to ascertain the most suitable sheep for the various districts. In some cases the fineness of the wool rivals that from the native source, and in all cases the weight and density of the fleece have been remarkably developed. As already intimated, while much of the land of Australia, particularly the interior sheep runs, will only carry a light sheep, much of the coastal regions will carry a much heavier sheep. Crosses of Leicester and Merino, Shropshire and Merino, etc., are here employed, the result being a sheep in its entirety more valuable, but a cross in which the wool is markedly affected. Thus New Zealand produces large quantities of cross-bred wool, such being almost a by-product of the foreign mutton trade.

American Breeds.—The first introduction of Merino sheep into the U.S.A. took place in 1801, and consisted of three sheep—one direct from Spain into the State of New York, and the other two from France into Massachusetts. It is probable that the latter were of the true Spanish blood. Following this, there were many importations from Spain, France, and Portugal, all of which are described as of first-class quality. Realising the marked suitability of many States for sheep-farming, and owing also to the great demand as sustained by tariffs for wool cloth since the days of the Civil War, much has been done to build up flocks of a first-class order. There are many varieties of Merinoes in the United States, the chief among which is the Vermont, a breed somewhat larger than the ordinary type and fleeced with a long, dense, though relatively coarse wool, heavily folded and thoroughly impregnated with yolk, enabling the sheep to combat the conditions of a somewhat severe winter. This

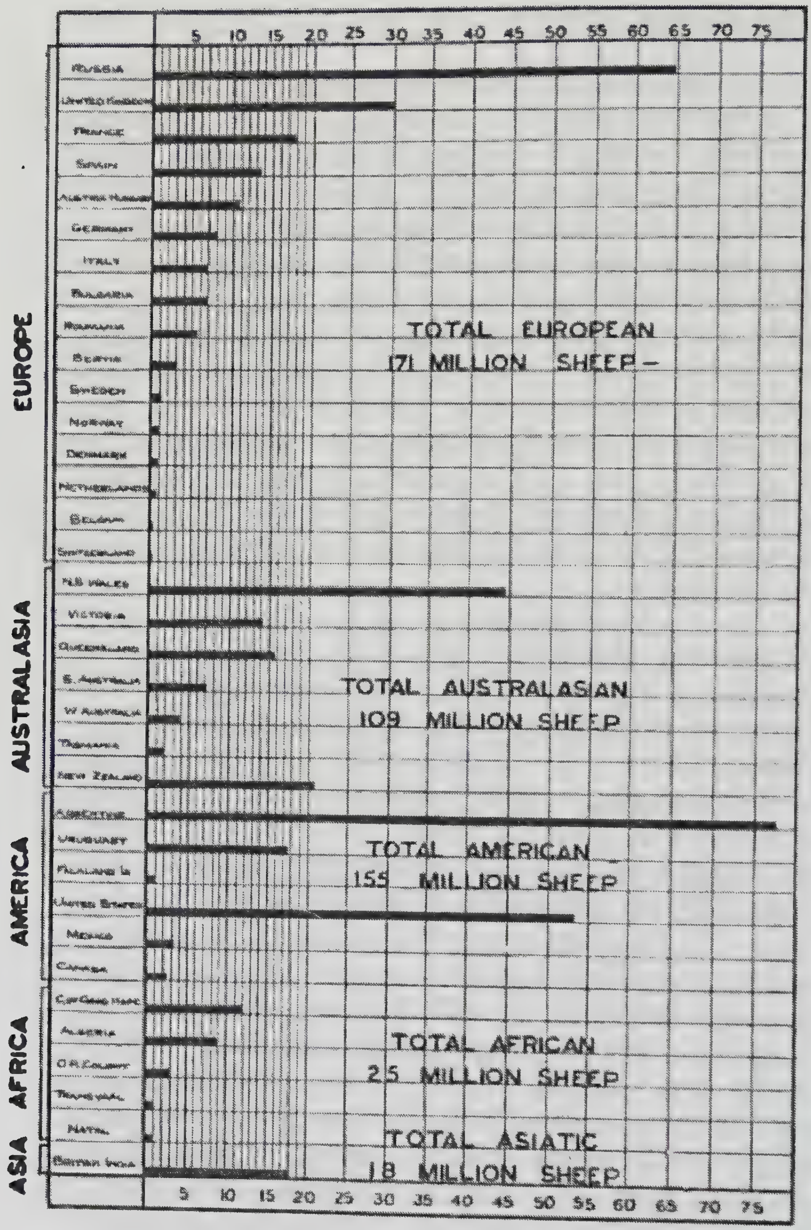


Fig. 18.—The World's Flocks in Million Sheep

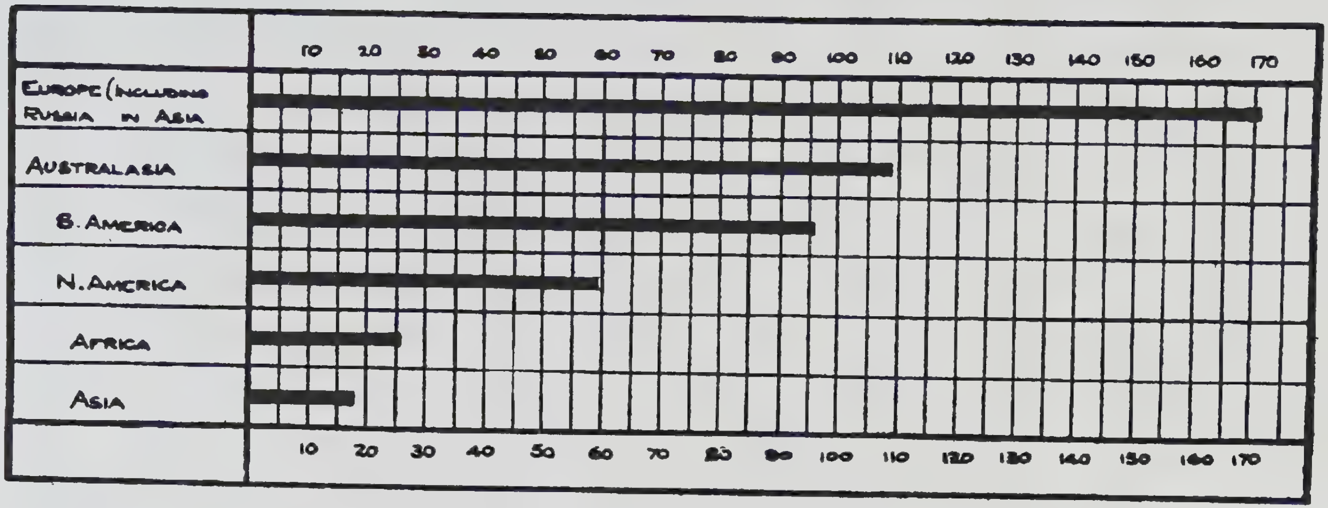


Fig. 19.—The World's Flocks in Million Sheep

breed has been crossed on the Australian Merino, and in some localities has proved very useful in increasing the weight of the fleece, which, in certain districts in New South Wales, for instance, through the climatical conditions obtaining, tends to become too light and fine.

Territory wool and its various crosses is perhaps best represented by the various Down crosses of England rather than by the cross-breds of Australasia.

Other Colonial and Foreign Breeds.—These are:

1. Native to the country and are in their unimproved state;
2. The native sheep developed through the use of the Merino as a cross; or
3. Improved by crossing on the British breeds.

The breeds of the following countries, claiming recognition on account of the quantity of wool yielded, need brief description. Order of importance is observed:

Cape Colony.—In Cape Colony and Natal the fat-tailed sheep is native; but the Merino has been introduced from Spain and cultivated with success. Much improvement, however, may yet be effected both in the form of the sheep and character of the fleece, the latter generally being of excellent fineness, but lacking strength. The wool is deficient in length also, owing to a system of double-clipping which prevails in many parts. Due to contact with sandy soil and the open condition of the fleece, considerable impurity is found in this wool. Great improvements are, however, being attempted, and much may be expected of Cape wools in the near future.

South America.—The wool grown here was formerly of the Spanish Merino type, and for a long time was

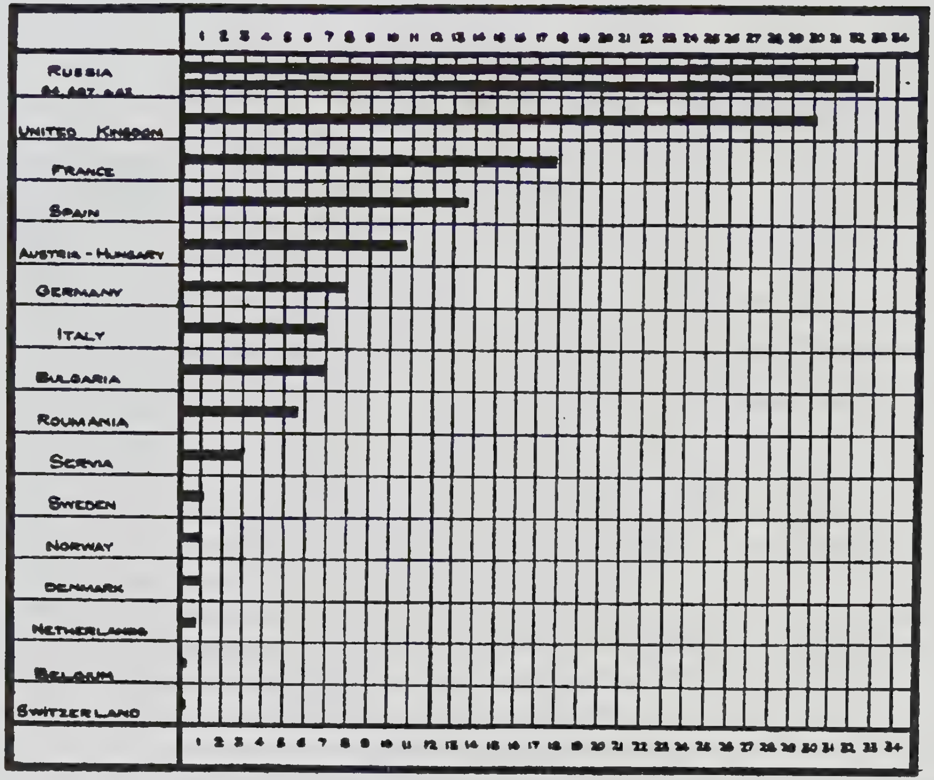
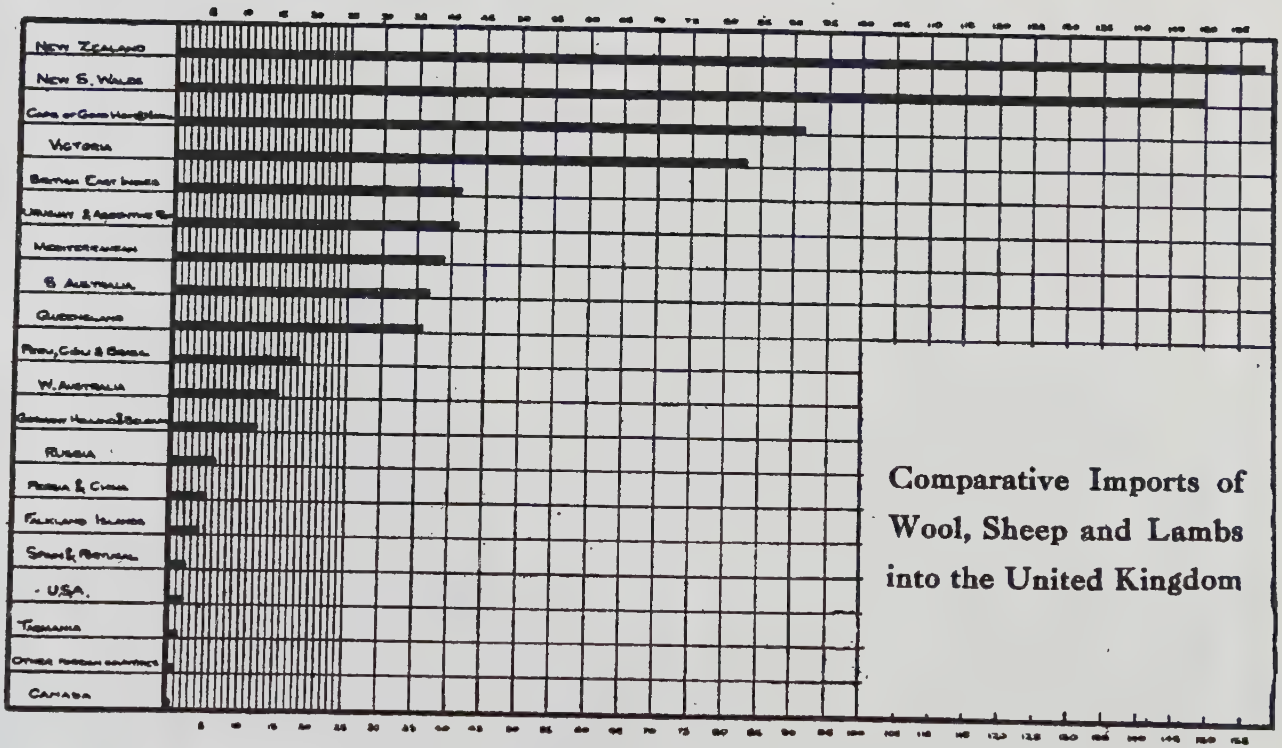


Fig. 20.—Production of European Wools in Millions of lbs.



New Zealand
New S. Wales
Victoria
S Australia
W. Australia
Russia
U.S.A.
Canada
Comparative Imports of
Wool, Sheep and Lambs
into the United Kingdom

Fig. 21.

allowed to degenerate. To-day wool-growing is considered of great importance in South America, and from a vast country, in most respects highly suitable for sheep, large quantities of very useful material are obtained. Many Merino sheep are reared, but the great export mutton industry centred in South America is responsible for a large number of cross-bred varieties of sheep, obtained by using the best English varieties of the Merino.

As an evidence of the numbers of sheep and the quantities of wool produced in the various wool-giving centres of the world, Figs. 18, 19, 20, and 21, which graphically illustrate the position of each, are well worth studying. They are self-explanatory. In Fig. 18 the sheep in each continental country are shown, and from this it will be readily noted which country possesses sufficient numbers to cause it to be important or otherwise as a wool producer. Fig. 19 shows the return for each continent in millions of sheep. In Fig. 20 the European wool production is illustrated, while from Fig. 21 the extent and character of the wool as manufactured or as bought for redistribution may be noted.

CHAPTER II

SHEEP-BREEDING AND MENDELISM

SHEEP may be bred simply as mutton-producing animals, or as wool-producing animals, or, as is more frequently the case, as both mutton and wool producing animals.

When, about 1902, the price of wool fell to something under 4d. per lb. for the rougher sorts of North Country wool, and to a proportionate figure for the finer and for the more lustrous kinds, the sheep-breeders in this country bred their sheep for the mutton and took little account of the wool; the same tendency was also to be noted in the Colonies about this time, particularly in the case of New Zealand, this colony having comparatively early developed the frozen-mutton trade.

As an example of a sheep bred for wool alone the Australian Merino sheep may be cited. This is a small carcass sheep, upon which is produced a quality of wool which so far has never been produced on a larger-bodied, good carcass sheep. But for the quality of its wool the full-blooded Merino could not exist for a day, save, possibly, in certain sandy tracts of the Australasian continent.

It is obvious that if a good carcass can be produced along with a characteristic wool a two-fold advantage will accrue; hence the many attempts at cross-breeding both in this country and in the Colonies. Sometimes, as in the case of the Australian Merino crosses, a larger

imported Merino type is crossed with the pure Australian Merino type to produce a heavier fleeced sheep without marked deterioration in the wool. In other cases a larger, earlier-maturing male sheep is mated with smaller ewes to obtain earlier maturing and larger carcass sheep with a constitution still fitted to their environment, as in the case of the many Down crosses now to be noted in the north of England. It is obvious that most flocks of sheep will be bred to obtain the utmost total income from both carcass and wool. This aspect of the case will be better understood by taking such an example as that given on p. 62, which shows that, at least under certain circumstances, the sheep-farmer cannot afford to breed the finest wools, or, rather, that it will pay him much better to breed a medium fine wool of greater length of staple, and, consequently of greater fleece weight, upon a larger-bodied sheep, than a very fine wool of less fleece weight upon a comparatively small-bodied sheep.

It is thus evident that quality of wool, weight of fleece, and weight of carcass markedly influence the sheep-breeder in his search for the most suitable types upon which to found his flocks. When the further influences of environment, and of the necessity for adapting the animal to the conditions under which it has to live,* are taken into account, it is evident that anything conducing to a better understanding and controlling of sheep-breeding in its varying aspects should be welcomed in a whole-hearted manner by those interested.

It is here proposed to indicate briefly the principles originally evolved about 1865 by Mendel, and so use-

* An interesting converse case of this occurred in the crossing of the drought-resisting Australian Merino with the Vermont Merino. When the drought came, 75 per cent. of the cross-bred flocks in some cases perished.

fully extended by Bateson, Wood, Punnett, Biffen and others, in the hope that sheep-breeders both at home and abroad may be induced to examine more closely the principles upon which they base their crossings and selections. If this be done, it seems reasonable to hope that less difficulty will be experienced in getting any particular type of animal or of fleece required, and that the fixing of a useful type may be accomplished within a very short period. To-day there is a saying in Australia to this effect: "Two generations to find a type, seventeen generations to fix it." Mendelian principles show how every possible type may be evolved at the second generation, and, further, how pure breeds may be discovered with a few trials conducted on clearly defined lines, with the result that five or six generations may be ample to fix absolutely any required type.

General Principles of Sheep-Breeding.—Up to the present time it may fairly be said that the sheep-breeder has been working in the dark, and he is undoubtedly to be complimented upon the results he has produced with such inadequate means as those upon which he has relied. His methods are few and simple. To produce variations in accordance with his requirements, he crosses likely breeds. To make the most of his opportunities, he selects or "culls"—i.e. he selects the most likely individuals for breeding purposes, or he weeds out from his flocks unlikely individuals from which he does not wish to breed. Then, from time to time, he may notice certain mutations, or "sports," as they are termed, and upon these his hopes of a new breed may be founded.

That selection in some form or other is the basis of the sheep-breeders' art there is no gainsaying, and from this point of view it only remains to emphasise the

necessity of the breeder keeping a true and useful type before him ; he must decide what he requires, bearing in mind the several main factors already noted, and also the limitations which his particular environment imposes.

It is in the effects of crossing and in the maintenance of type that the first real difficulties are encountered. Just as with poultry, pigeons, etc., the crossings of breeds frequently result in unthought of and unsought for varieties, and until Mendel's work was brought to light, these seeming irregularities were uncontrollable, and amenable to no known law. It will presently be our object to show that at least the greater number of the variations referred to may be scientifically explained, and that well-directed experiment will probably render possible the positive controlling of these variations.

The maintenance of stability of type is, perhaps, the greatest difficulty which the breeder has to encounter. Let us clear the ground at once, however, by stating that all such phenomena termed "reversions to type," "throwing back," and some apparent "sports" are readily explained by Mendel's laws, and with careful experiment should usually be readily controlled.

There is, however, another type of variation which is possibly not so readily controllable, and that is what may be termed acquired variation. Attention was first drawn to the possibilities of Australia as a wool-growing country by reason of the remarkable changes which the fleeces of comparatively rough sheep underwent: changes which could only be ascribed to the direct action of the environment through the individual. Take the Australian Merino sheep out of its natural environment, and it will lose its acquired characteristics. A similar example is to be noted in the lustre wool of Lincolnshire. Take the Lincoln sheep away from the

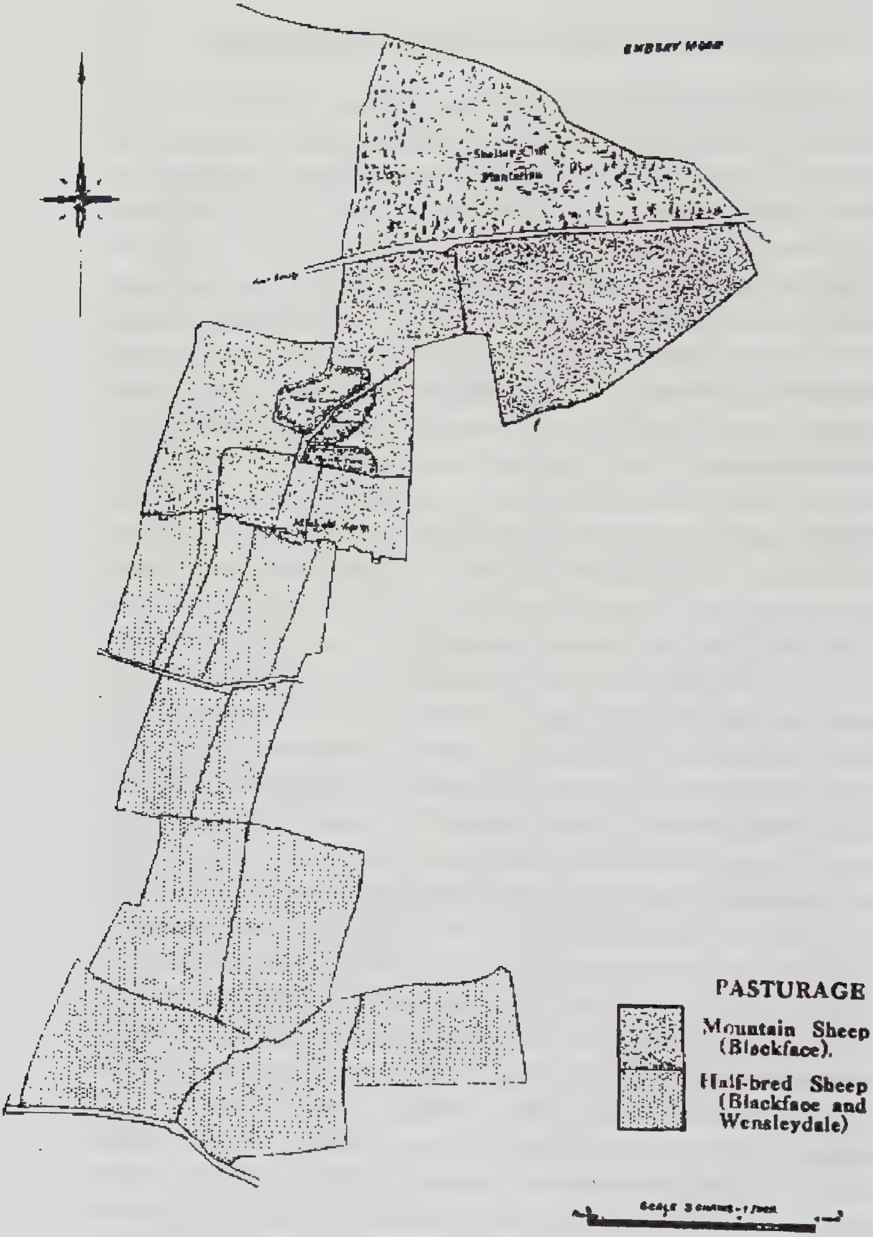


Fig. 22.—Plan of Sheep Farm

rich pasturage and artificial feeding of Lincolnshire, and place it on the chalk downs of the southern counties, and its lustre is at once impaired. In both these cases it seems probable that by selection a type of sheep has been evolved whose constitution responds to the particular environment in question to the fullest possible extent, and by inference one would expect such a type to be impaired in its responsiveness to environment other than that for which it had been specially selected. There may be limits to the possibilities of selection, but it is not impossible—to take a trite case—that a Merino-woolled breed might be found whose constitution would respond to the environment of the English climate in such a way that Merino wool would still be produced. The fact that Merino rams have been kept by Professor Wood on the Cambridge University Farm for some years without marked deterioration in the quality of the wool, suggests that the last word has not been written on this matter. It seems possible that the stability of any breed may, in part, depend upon the time-factor—in other words, upon the length of time that this breed has been maintained in a state of equilibrium, and that breed may possibly dominate environment within reasonable limits.

Perhaps the foregoing remarks may be summed up in the three points specially noted by Professors Wood and Punnett :—

I. The necessity of care in selection ;

II. The occurrence of two kinds of variation, acquired* and genetic ; the latter only being inherited ;

* These writers' citing a fat heifer as an example of this is hardly conclusive, as the quality of fattening may only be genetic, and as such may be transmitted to offspring. However, there may obviously be individual variations dependent upon accidental influences, which may most truly and usefully be considered as most closely related to these influences, and, consequently, at least, not wholly genetic.

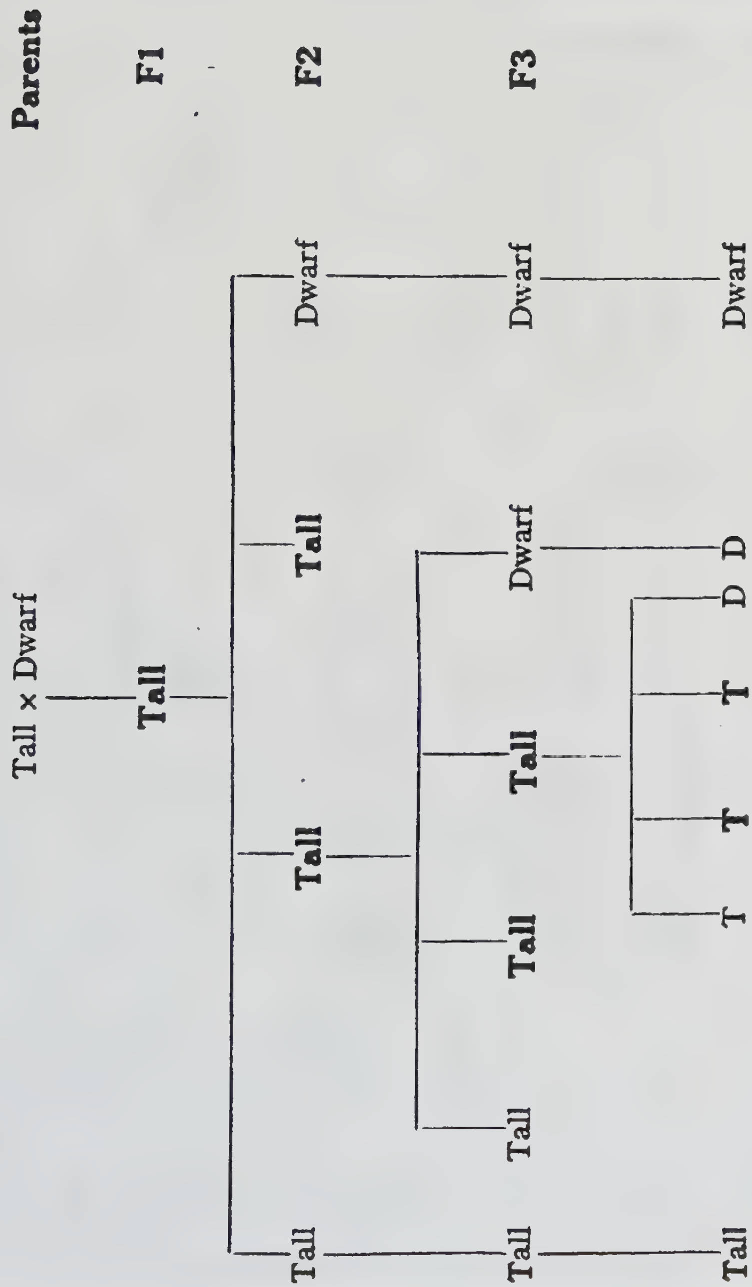
III. The need for applying an actual breeding test to any individual which it appears desirable to perpetuate before definitely deciding to keep it for stock.

Selection has been dealt with at some length. Mendel's principles of heredity must now claim our careful consideration.

Mendel's Principles of Heredity.—If Darwin and Wallace in the domains of biology and philosophy dominated the thought of the latter half of the nineteenth century, Mendel has at least as fully dominated the thought of the early years of the twentieth century in the wonderful vistas he has opened up in practical biology, and more particularly in what is now termed "Genetics." Mendel's work is most readily apprehended by taking a simple example, such as that ot the crossing of tall and dwarf peas, and representing it graphically as on page 41.

From this it appears that the result of crossing a tall and dwarf pea is in the first generation (F1) an *apparent* tall pea. This is expressed by stating that the tall pea is dominant to the dwarf pea, and the dwarf pea is recessive to the tall pea. On crossing the F1 generation with itself it will be noticed that in the second generation (F2) the result is plants in the proportion of three tall plants to one dwarf. The main point to notice, however, is that of the tall plants one only will breed true, the other two being impure, and corresponding exactly with the tall in F1 generation; while the one dwarf plant, the recessive, is also pure. This must be fully realised, as it forms the groundwork of Mendel's principles.

The explanation of these results may be expressed most convincingly by the following diagram (Fig.



NOTE :—Strong type indicates dominant hybrids.

23) from Professor Punnett's well-known work on "Mendelism" :—

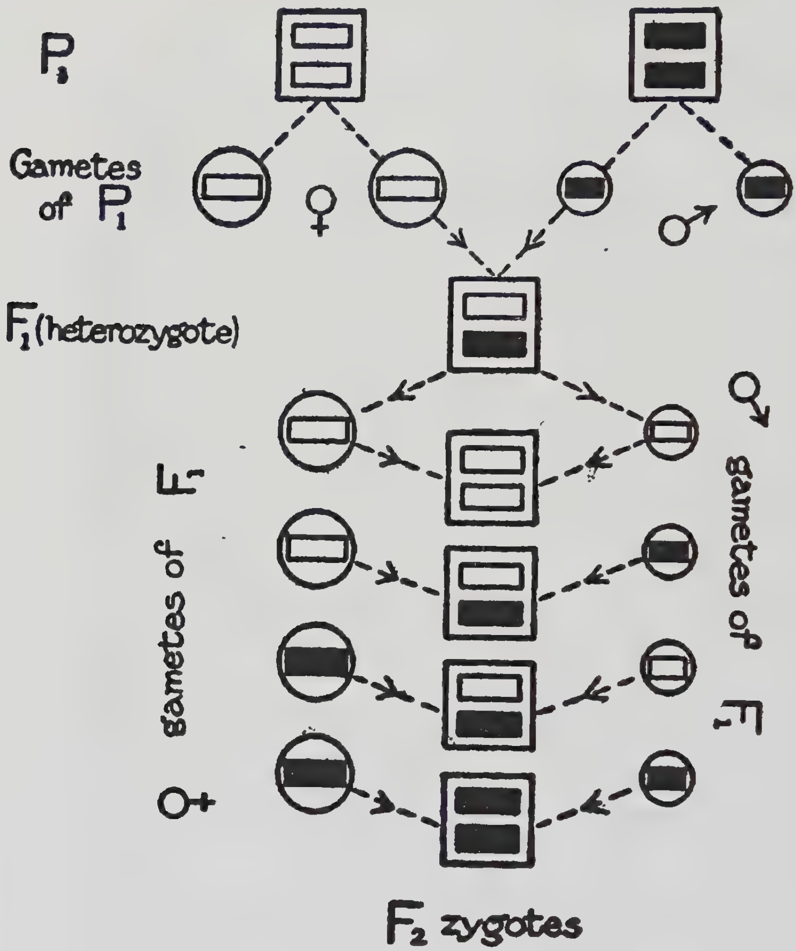


Fig. 23

From this it will be realised that if the male or female gametes of one parent be fertilised with the female or male gametes of the other parent, the result

is that the F_1 generation *of plants* is heterozygous (although appearing like the original tall plant), and gives rise to equal numbers of tall and dwarf gametes, which fertilising one another, by the laws of chance, so to speak, give rise to three types of zygotes in the F_2 generation, of which two are homogeneous or homozygous and two heterogeneous or heterozygous.

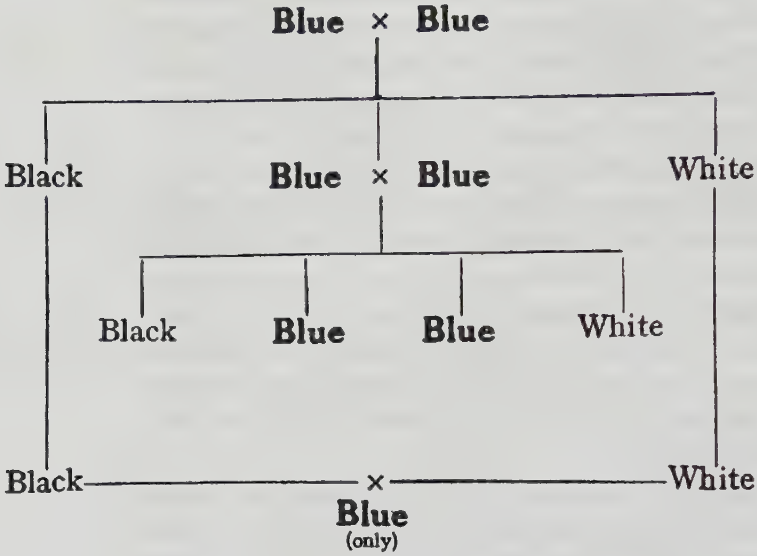
The thorough comprehension of this diagram clears the way for the enunciation of the main principle which Mendel discovered—viz., what is termed *the segregation of the gametes:* i.e. whether a plant is heterozygous or not it produces gametes, each of which is pure. If the plant is pure tall, it naturally produces gametes pure tall only; but if it be a hybrid, i.e. heterozygous, it produces pure tall and pure dwarf gametes *in equal numbers.*

This is Mendel's discovery put in its simplest form, and it only remains for us here to touch briefly upon certain apparent complications, and then to deal with its application in sheep-breeding.

Perhaps the first real difficulty which occurs is in some such suggestion as this: Suppose a tall pure pea is crossed with a tall impure, or a tall impure with a dwarf pure, what is the result? *Exactly what would be expected, working on the lines indicated by Prof. Punnett's diagram.* This has been tested many times and in many ways, and the results, even to the proportion of the several kinds, are always the same.

The next difficulty has reference to cases in which the F_1 generation is different from either parent, as in the case, for example, of the blue Andalusian fowls. This fowl can only be produced in the F_1 generation, its parents being either the heterozygous blues, or black crossed with white, or blue crossed with either the black or the white, the proportionate numbers being

always what would be expected. This crossing is illustrated as follows :—



NOTE :—Strong type indicates dominant hybrids.

It will at once be evident that most of what are termed "sports" may be the result of some such conbination as this : Thus, two white peas may give in the F1 generation a pink pea, and a white and a pink parent primula may give a white in the F1 generation. In the case of the two whites giving the pink, it is probable that one carries the colour factor, and the other the striking or, as it were, mordanting factor; hence the colour in the heterozygous plant. In many cases a presence and absence theory seems to give the key to observed results, but there is not space here to go into the many tested and authenticated cases. *There is really nothing haphazard in these results.*

Perhaps the greatest difficulty of all lies in defining what may be termed "unit characters." Thus, in the

first example cited, the gametes carries the factor of tallness to the exclusion of the dwarf characteristics, or the gametes carries the dwarf characteristics to the exclusion of the tall characteristics, and never carries both. If one could split up all characteristics into pairs of opposites such as these, many of the difficulties in the application of Mendel's principles would vanish. Unfortunately this can rarely be done. For example, it seems, with reference to sheep, that they either have horns or have not horns; here we have a pair of characters. On the other hand, it seems probable that the black faces of certain breeds of sheep is not a unit character, but is a compound of say black nose, black eye-rings, and so on. And in the same way it may turn out that the quality of the wool is not a unit character, but two or more characters compounded of length, fineness, etc.

In all breeding work intended to have an economic bearing, the first step is to carry out what may be called a Mendelian analysis. To do this breeds with and without the desired characters are crossed and the way in which the various points segregate in the second generation is noted. For instance, in the second generation from the Dorset-Suffolk Cross, it was noted that very few real black faces were obtained, but that the common forms had black noses or black spectacles, or both. Such an analysis shows that the black face is not a unit character, but is made up of black on nose, black round eyes, and so on. Having thus analysed the black face, it would then be possible to proceed to build it up again.

Another difficulty easily overcome in the plant world, but a real stumbling-block in the animal world, is the necessity of producing large numbers of crosses, so that every possible combination is produced; and

more particularly in finally selecting the pure individuals to breed from. Some of these difficulties will be referred to in dealing directly with sheep-breeding, but so many have been overcome that it seems more than possible that the present seeming exceptions will ultimately be brought under the law. In order that the reader may not run away with the idea that these results are what the so-called practical man terms "theoretical," he is referred to the work of the Cambridge University School of Agriculture in the production of wheats, etc., which already have been successfully placed on the market.

Mendel's Principles Applied in Sheep-Breeding—In sheep the difficulties of obtaining the type required are complicated by the number of factors to be taken into account. Professor Wood has already worked some interesting crosses out, and has kindly allowed his results freely to be drawn upon. Perhaps the most interesting is that in which the white-faced horned Dorset sheep has been crossed with the black-faced hornless Suffolk sheep. The results may be indicated diagrammatically as on page 47.

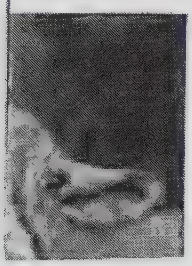
In Figs. 24 and 26 photographs of the actual results obtained are reproduced.

From these results the following two deductions have been made :—

A. Every possible type that can result from any given cross appears in the second generation, provided that in this generation enough individuals are produced.

B. Of the individuals of every one of these possible types a certain proportion are already fixed, and if these are picked out no further selection is necessary to establish the type.

Suffolk Ram



Dorset (Horned, White Face) × Suffolk (Hornless, Black Face)

Rams (Horned) ← Speckled Faces → Ewes (Hornless)

×

White Face		Speckled Face		Black Face	
Horned Ram	Hornless Ram	Horned Ram	Hornless Ewe	Horned Ewe	Hornless Ram

NOTE:—These are six only of the re-combinations illustrating what has been actually proved to take place.

These two deductions will be fully understood by reference to the diagram on the previous page of the crossing of the Dorset and Suffolk sheep.

Note should here be made, however, that the term "fixed" applies to unit characters only. Thus an animal may be fixed for one character but heterozygous for other characters.

The difficulty in picking out the pure-bred individuals is really the crux of the matter now. This may usually be done by mating with known recessives. But the whole question is so complex that the reader must be referred to the standard works now to be obtained on the subject.*

* * * * * *

That the principles here briefly dealt with well merit the sheep-breeder's careful consideration will at once be conceded. When the value of definite breeds of sheep in particular situations and for particular purposes is considered, then it is evident that any means of controlling the type of sheep produced, and of fixing the type when produced, is of the greatest possible interest, and probable value, to sheep-breeders. Damp, low-lying districts require the foot-rot, fluke-withstanding Romney Marsh sheep. Some districts of Australia require a light sheep, and some will carry a heavy sheep. The mountainous districts of Scotland, Wales and Switzerland each requires its own type, and so forth. It will be a strange thing if in the near future the large sheep-breeders both at home and abroad do not employ to marked advantage the principles here given in outline.

In conclusion, reference may be made to experiments at present being conducted by Professor Wood on the Cambridge University Farm. In this case Merino rams have been mated with heavy-fleeced, large-bodied

* *See* Darbishire's "Breeding and the Mendelian Discovery."

Progeny all white faced.

Fig. 25

* The F_2 ram is pure hornless and pure white faced

F$_2$* Ram

Suffolk Ewe

Progeny all hornless

Fig. 26

* The F$_2$ ram is pure hornless and pure white faced

Shropshire ewes. In the F1 generation there is a certain variation among both rams and ewes, showing that the allelomorphic pairs are somewhat complex; but, upon the whole, both rams and ewes appear to be tending towards the Shropshire carcass and the Merino wool. The wool from both rams and ewes varies from about a 50's quality to a 64's quality, but the bulk would be considered a good typical "come-back." All the rams possess horns or scurs but the size of the horn varies considerably. From these slightly varying half-bred rams, a selection of two or three is being made, so far as possible fine-woolled heavy carcass individuals being chosen. Mating these with the half-bred ewes, every variety of Merino-Shropshire combination should appear in the F2 generation. From a close examination of the types which appear it should be possible to draw some conclusions as to the mode of inheritance of wool and mutton, and possibly to analyse the unit characters on which these economic points depend. There will then remain the difficult task of selecting the fixed-bred sheep which possesses the wool qualities of the Merino with the carcass characteristics of the Shropshire. The testing of individuals of this generation may be most difficult, but there is every reason to hope that in the conducting of these experiments principles of great value to the sheep-breeder will be evolved.

CHAPTER III

WOOLS, HAIRS, AND THE RE-MANUFACTURED MATERIALS

British Wools and their Uses.—No country supplies a greater range of wool qualities than Great Britain. These are suitable for a large variety of fabrics, and four classes may conveniently be made.

1. Long and lustrous wools.
2. Short wools.
3. Mountain-bred wools.
4. Highland wools.

1. **Long and lustrous wools.**—These wools are characterised by length and lustre, and are usually remarkable for strength and soundness. As an example of degree to which the latter qualities are present the use of Lincoln and Leicester wools for covering the squeeze rollers, which have to do most heavy work, in scouring machines may be cited. These wools are typical worsted materials, being straight-fibred and capable of conversion into a parallel fibred yarn of marked smoothness and lustre. They are, naturally, mostly used in the production of bright fabrics, which are most durable, and which possess most excellent draping properties.

2. **Short Wools.**—These differ markedly from the foregoing. Their striking feature is a firm and clearly defined curliness, which makes them specially suitable

for hosiery fabrics in which fullness and softness are very important characteristics. These wools are usually of a good colour, and as they are fine fibred, they admit of the production of light-weight goods. They are not remarkable for strength, but except in fleeces which are exceptionally weak this is not a serious disadvantage in the fabrics for which they are suited. Although they do not usually felt well they are employed to a considerable extent in the woollen industry, as they give fullness and springiness to the fabric.

3. **The Mountain-bred Wools.**—These have not the nature or character of either the long or short types previously mentioned. Owing to careless breeding and the severe climatic conditions under which they live, they lack brightness, and they are very irregular in fibre and staple. Marked differences are also noticeable in staples from the various positions of the fleece, which cause considerable trouble to both staplers and spinners. Almost all these wools are markedly characterised by kemps which affect both the spinning and the dyeing of the material. The fibre, further, is rough, wiry, and poor in cohering qualities, and consequently it neither spins well nor handles kindly. Still, for low, thick yarns and fabrics of both the woollen and worsted types, these wools are cheap and serviceable. Cheviot wool is the most important of this class, having made its name in connection with Scotch tweeds, with reference to which it is useful to note that what may be termed the defects of the wool have been made the basis of a most useful class of yarn and fabric.

4. **Highland Wools.**—These partake of the nature of Down breeds, but lack character and trueness. Save in Irish wools—which are somewhat better than the other types—they are irregular and wasty in staple, thick in fibre, and contain many kemps. Their spinning

VARIATIONS OF BRITISH TYPES OF WOOL

Type of Wool	*Length*	*Strength*	*General Appearance*		*Handle*	*Weight of Fleece (Average)*	*Quality (Average)*	*Uses*
			Form of Staple	*Colour or Lustre*				
	Inches					Pounds		
LINCOLN	12	Very strong	Very firm, straight-tapered	Very lustrous	Fairly soft	12	36's	Plain and fancy lustre and demi-lustre dress fabrics; also imitation serges.
LEICESTER	10	„	Firm, straight-fibred and tapered	„	„	10	40's	
COTSWOLD	8	Strong	Firm, deep-grown, slightly curly	Lustrous	Soft	8	44's	
BORDER-LEICESTER	10	„	Fairly firm, slightly curly, tapered	Very lustrous	Fairly soft	10	44's	
WENSLEYDALE	9	„	Fairly firm, tapered, curly	Lustrous	Not soft	9	36's	
DEVON (BAMPTON)	10	„	„ „	„	Soft	10	36's	
DEVON (SOUTHAM)	9	„	„ „	„	„	9	40's	
NEW OXFORD	8	„	Fairly firm, slightly curly	„	„	8	46's	
ROMNEY (KENT)	6	Fairly strong	Full and open, curly	Whitish, medium lustre	Very soft	7	46's	
SOUTHDOWN	3	„	Thick, dense, and curly	Very white	„	4½	56's	Dress fabrics, hosieries, flannels
SHROPSHIRE-DOWN	4½	„	Fairly dense and curly	„	Soft	6	50's-56's	
HAMPSHIRE-DOWN	3½	„	Thick, dense, and curly	„	„	5	50's-56's	
OXFORD-DOWN	4	„	Fairly full and open, curly	White	Very soft	6	50's	

VARIATIONS OF BRITISH TYPES OF WOOL—(*continued*)

Type of Wool	*Length*	*Strength*	*General Appearance*: *Form of Staple*	*General Appearance*: *Colour or Lustre*	*Handle*	*Weight of Fleece (Average)*	*Quality (Average)*	*Uses*
	Inches					Pounds		
SUFFOLK-DOWN	5	Fairly strong	Full and open, curly	White	Soft	6	50's	Dress fabrics, hoseries, flannels
RYELAND .	3	Strong	Thick and dense, curly	Very white and silky	Very soft	4½	56's	
DORSET .	4	Fairly strong	Fairly full and open, fuirly curly	White	Soft	4	50's	
BLACKFACE .	10	Weak	Straight and shaggy, un-uniform (kempy)	Grey, poor lustre	Harsh	4	32's	Tweeds (Cheviot wool type), woollens, carpets, low hosieries, blankets
CHEVIOT .	4½	Fairly strong	Full and thick, curly	Fairly white ("Blue" wool)	Fairly soft	4	46's-50's	
LONK . .	5	"	Full and open, tapered	Fairly white	"	4	46's	
HERDWICK .	8	Weak	Rough and open (kempy)	Grey, poor lustre	Harsh	3½	32's	
"NORTH" .	7	Strong	Full, uniform, curly	White and bright	Soft	7	46's	
PENISTONE .	8	Fairly strong	Royal and open, straight	Whitish, fairly bright	Harsh	4½	32's	
EXMOOR . .	4	"	Full and open	" "	Soft	4	36's	
WELSH . .	6	"	Rough, un-uniform, kempy	White	"	3½	36's	Flannels, hosieries low woollens, "homespuns" hat fabrics.
IRISH . . .	7	Strong	Clearly dened	"	Fairly soft	6	46's-50's	
SHETLAND .	7	Fairly strong	Rough, un-uniform (kempy)	White and bright	"	4	36's	

capacity is consequently poor, but they are suitable for thick goods of low quality. They form very largely the raw material upon which the home industries in flannels, dress goods, and tweeds is based.

The lists on pp. 52 and 53 give all the variations to be found in the British types. This should be studied along with Fig. 27, in which the staples from a representative series of these breeds are illustrated.

Continental Wools and their Uses.—Of the Continental wools the Merino is by far the most important. Produced originally in Spain, the growing of this wool gradually spread through Germany (Saxony and Silesia), France, Italy, Austria, and Russia. The quantity coming to England is now very small, the bulk being manufactured in the nearest industrial centre to that in which the wool is grown.

Spanish Merino was formerly pre-eminent, but during the middle of last century it was rivalled by the Saxony and Silesian types of wools, which in fineness are exceeded by none. French Merino wool is very fine, but is not so dense as the foregoing; while Italian Merino, though good, is slightly lower in general quality. Of the Russian type, Odessa wool, from the Crimean district, is worthy of note. All these types possess good spinning qualities, are excellent in colour, and are very suitable for milling purposes.

Other Continental wools are not very important as regards British trade. They are yielded by (1) native breeds, (2) native breeds as improved by Merino of the Spanish type, and (3) English crosses on native breeds. In Spain the Chunah breed produces long wool, evidencing Cotswold blood—this is employed in the production of low woollen goods. France produces wool of a mountain-breed type, which in some cases

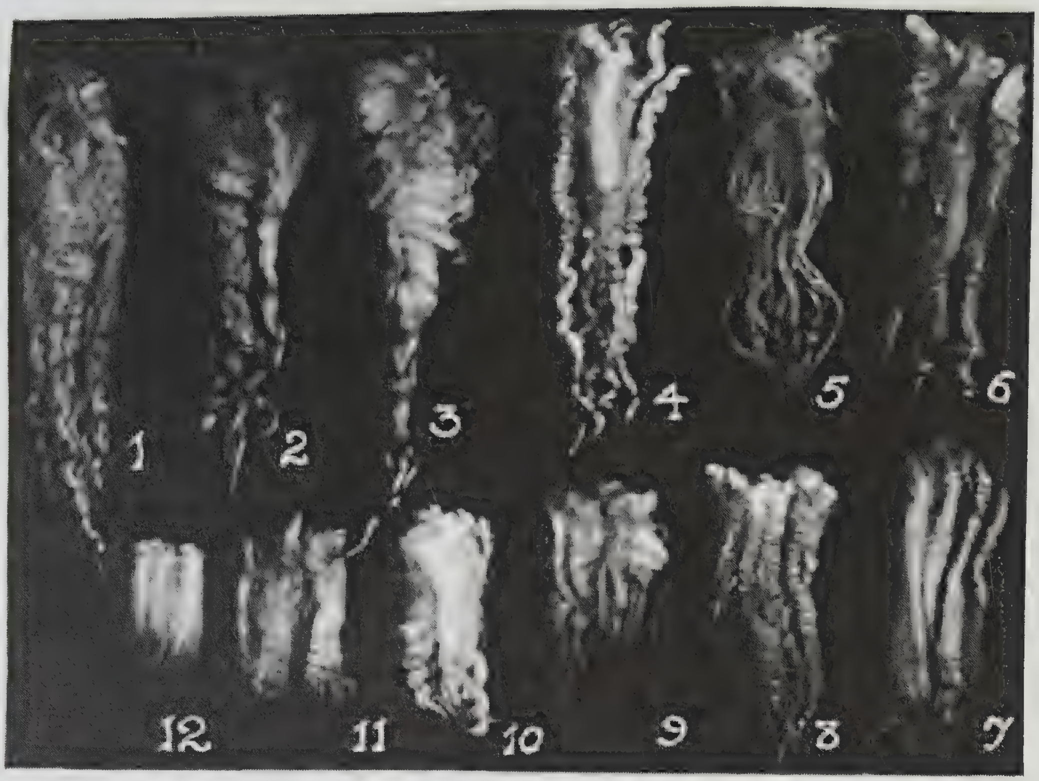


Fig. 27.—Range of British Wools

1 Lincoln Hog 2 Leicester Hog 3 Nottingham Hog 4 Irish Hog 5 Blackface 6 Half-bred
7 Staffordshire 8 North Hog 9 Lonk 10 Kent 11 Shropshire 12 Southdown

resembles the English medium-wool breeds so far as softness is concerned. Germany produces wool from crosses of the Merino and also the long-wool sheep with the native breeds, the bulk being of the Merino cross native. In Holland and Belgium many varieties of middle and long-wool types exist. Russia produces many varieties of wool, ranging from the coarse hairy type to the typical medium wool of England, the British type having been crossed on the native breed. The wool of the Wallachian sheep is extensively grown in the Danubian principalities. It is of fine and soft character, but is much deteriorated by the presence of strong hairs. It is mostly manufactured locally, and forms the chief covering of the peasants. Crossing with the Spanish Merino has effected valuable improvements in this wool.

Iceland wool is of a low quality; it forms a species of down at the base of a longer hair covering. It is useful for low fabrics, rugs, blankets, etc. Wools from Sweden, Norway, and Denmark are similar in character —that is, they are coarse and open and much mixed with strong hair. Crossing has been carried out with both the Merino and English long wool, more especially the former, with fair success. Large quantities of these wools are now available for manufacturing purposes; some of it finds employment in this country and much in Germany.

Asiatic Wools and their Uses.—In Asia varieties of the flat-tailed and fat-rumped sheep abound, giving a coarse, rough, and matted wool, which is only suitable for carpets and low fabrics. Such are of considerable importance to this country. Large consignments from Bagdad, which have been grown in Palestine, Syria, and Persia, are shipped to Europe,

while large quantities are also grown in India and China. These latter probably come to us as East Indian wools. Fine wool, but brown and grey in colour, is grown in Persia (Kerman district), some of which finds local employment in the high-class fabrics, carpets, etc., and other in the European soft-goods trade. Chief among Indian wools is the previously mentioned Cashmere.

African Wools and their Uses.—Save in the case of Cape Colony (to be dealt with later), where much useful wool is grown, Africa cannot be included among the important wool-producing countries of the world. Of the sheep, the fat-tailed varieties extensively abound. On the Red Sea borders and East Coast much coarse hair is produced. In Egypt and in Abyssinia softer and silkier wool is grown, the type being more Persian in character. From the mountain breeds of many horned sheep long and coarse wool is obtained. In the western parts of the continent, in Guinea and in Angola, a variety of breeds yield a corresponding variety of wools; from Angola, soft and short brown hair, with fine wool underneath, is obtained, while on the Congo very fine and variegated wool and hair are grown. The Guinea breeds, as a rule, give long, strong hair, usually white, but sometimes varie-coloured. On the West Coast towards the north, in Morocco, Algiers, Tunis, and Tripoli the wool is generally poor in character, being grown upon badly-bred sheep of the Guinea breed. Through the improvement of breeds and European influence, wool of a somewhat better type may now be expected. These wools are of little practical value to Europe, those which do come being employed for felts, low blankets, and rugs.

Fig. 28.—Pure Australian Merino Sheep

Fig. 29.—Australian × Vermont Merino Sheep

Colonial Wools and their Uses.—Australian wools.—Australia may reasonably be called the world's wool farm, although it is interesting to note that South America is now an important competitor. No other country produces wools of such length, strength, fineness, colour, and milling properties. With wools grown under such varied conditions as prevail on the Australian continent—that is, variations in soil, climate, and rainfall—it is impossible here to make more than a very general reference to differences that exist between types. Formerly Merino wool was exclusively grown; to-day, largely owing to the frozen mutton trade, there is a very considerable proportion (roughly about one-fourth) of cross-bred wool grown. Pure English-bred wools, such as lustres, Downs, Romney Marsh, etc., are also to be found.

Merino Wools.—Of the Merinoes two breed types are to be noted, namely pure Australian (Fig. 28) and Australian × American (Vermont) (Fig. 29). The introduction of the Vermont-Merino into Australia is a very interesting economic study. In certain districts of Australia in which heat and dryness are dominant—the Riverina district of New South Wales, for example—great difficulties were experienced in obtaining a profitable weight of fleece and in preserving the strength of fibre. Crossing with the Vermont was introduced to prevent deterioration in respect of these qualities. It is interesting to note that the Vermont breed was developed in the State of that name in the North American continent, and was naturally bred very heavy and dense in fleece, and extremely yolky, to withstand the rigorous winters then prevailing. Possibly some of the Vermont characteristics must also be attributed to the rich food and natural environment. When crossed on the fine Austra-

lian Merino, the Vermont affected both the constitution of the resultant sheep and the character of the wool. (See No. 6, Fig. 30, and compare this with No. 7, which is pure Australian Merino.) In some cases disastrous results were produced through the too marked dominance of the Vermont, the wool being reduced from a Merino to a fine cross-bred type. Worse still, however, the constitution of the sheep, which might have withstood the rigours of a North American winter, naturally was unable to withstand heat and drought. Thus, in the drought of 1897–8 millions of these unacclimatised Merino crosses died off. Some Australian breeders, however, have made a marked success of this cross, through a very careful and gradual introduction of the Vermont. Thus they have been able to keep the quality of the wool within reasonable limits, to avoid too much yolk and at the same time to increase the weight of the fleece by at least one-third. The best type of Australian-Vermont wool has been in great demand, as being a very useful general purpose wool, which in many cases has almost equalled the price of the pure-bred Australian Merino, the fleeces of which weigh considerably less. It is thus natural for the wool farmer—at least, in some cases—to look favourably on the Vermont cross. At present the tendency is to breed back to the fine-wool types. This tendency is also to be noted in the United States of America. Possibly this is due to the general feeling that on the whole the price lost in quality can hardly be compensated for by the gain in extra weight.

Consequent on the natural endeavour to breed sheep specially suited to particular localities, and also to the natural effect that environment, in conjunction with breed, has on the wool, three classes of Merino wools are now in evidence. These are respec-

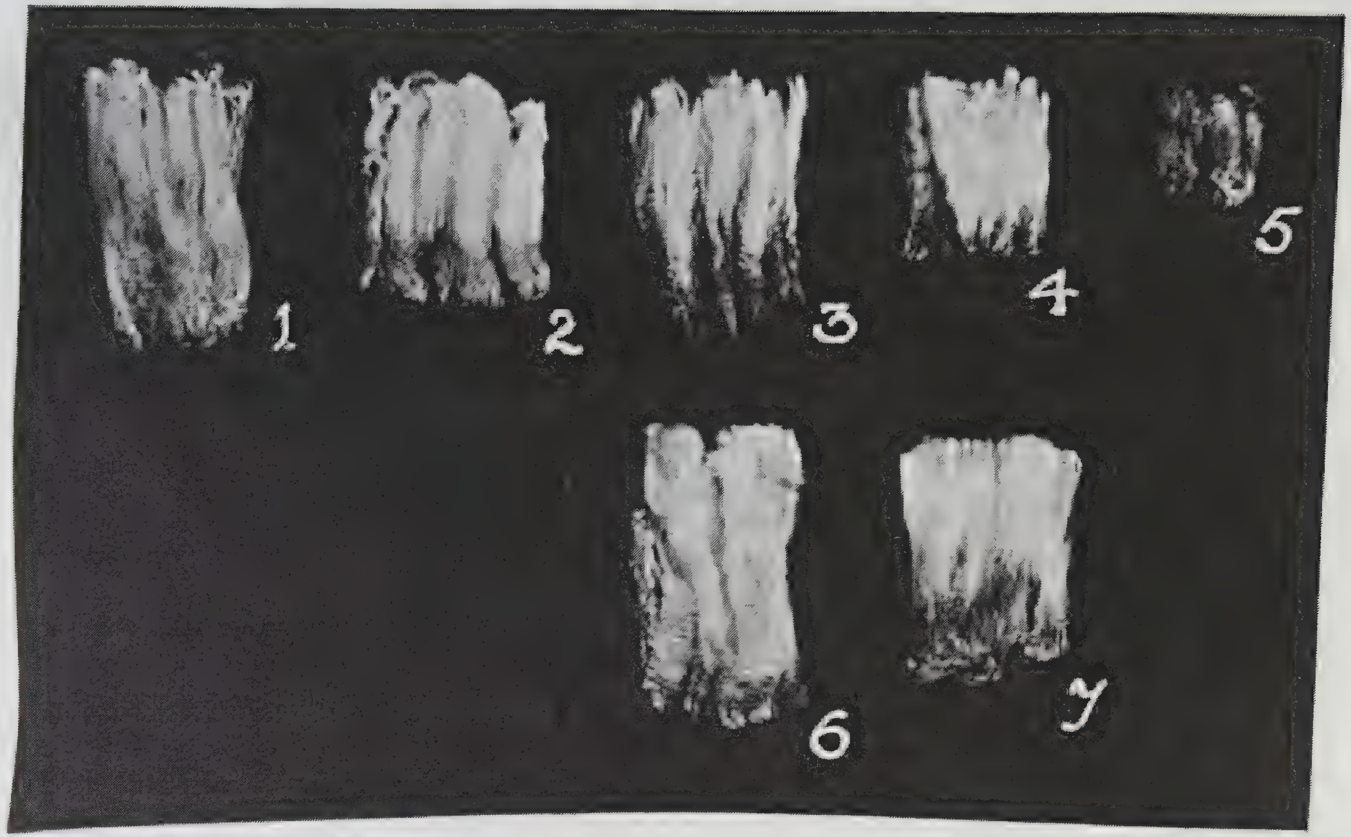


Fig. 30.—Types of Merino Wools

1 Australian Combing 2 Tasmanian Combing 3 Cape Combing 4 Monte-Video Combing 5 Cape Clothing
6 Vermont-Australian Merino 7 Pure Australian Merino

tively fine, medium, and strong, of which the second class is by far the largest. The following are details of these types :— (List)

The combing varieties of the first class are employed for Cashmeres, Italians, and worsted coatings, while the shorter, or "clothing," are made into the finest woollens and billiard cloths. Of the medium class the longer varieties go into worsted coatings and dress goods, and the shorter varieties into woollens, army cloths, etc. The stronger Merinoes are employed similarly to the medium class for cheaper fabrics, and are used for blending with crossbreds and for hosieries.

Types Produced in the Various Australian States. — In New South Wales the conditions under which sheep are reared are many and various. In the hilly districts of the eastern portions they are such that fine-bred sheep yielding the highest class of wool may be carried in large numbers.

DETAILS OF TYPES OF MERINO WOOLS

Class	*Quality*	*Length in Staple*	*Fineness*	*Softness*	*Colour*	*Waviness*	*Impurity*	*Appearance of Staple*
		Inches						
*Fine .	70's–90's	2½	1-1600 in. and upwards	Very soft	Very white	26 crimps per in.	48–52 %	Clearly defined, dense, and uniform
†Medium	60's–64's	3½	1-1200 in.–1-1400 in.	Soft	White	20 crimps per in.	50–54 %	Uniform, bold growth, and robust,
‡Strong	58's	4	1-1000 in. and below	Fairly soft	Fairly white	16 crimps per in.	52–56 %	Fairly uniform, open; not distinct

* *See* No. 7, Fig. 30. † *See* No. 1, Fig. 30. ‡ *See* No. 6, Fig. 30.

In the central division, which is flat and warm, medium and strong types, producing a useful wool, are most in evidence. In the western portion, which is open, hot, and dry, the medium and strong types of wool are produced, principally the latter. The wool is somewhat dry and open in staple, and proves very wasteful. Compared with the very best Australian types, New South Wales wools are not quite so good; they are somewhat dryer and liable to weakness, and, consequently, do not yield the finest counts. Again, a number of these wools are very heavy in sand, which makes it difficult to estimate the yield. The wool of New South Wales is largely classed and sold in Sydney, but much also crosses the border to Melbourne and is sold at Port Philip; while some passes to South Australia and is sold as "Adelaide" wool.

Victorian wools are best represented by the well-known Port Philip wool, in which district are to be found conditions favouring growth of fine and strong wool of an unrivalled character. No flocks have received more careful attention. The length and fineness of these wools are exceptional, and combined as they are with soundness, a perfect whiteness and an excellent milling capacity, they enable the spinner to produce the finest tops ranging up to 90's to 100's quality. The fleeces are usually in a very clean condition; they yield well, and the amount of impurity or "sinkage" can be accurately judged.

In South Australia—chiefly noted for Adelaide wool—a staple of the stronger class is produced. These wools, however, occupy a foremost position in their class. In length and soundness they are exceptional, and, further, are fairly dense and full, and of marked fineness. Such wools, however, contain much yolk and often are very sandy. While clips from most other

States for the year 1889 were below the average, owing to the adverse climatic conditions, this clip retained all its characteristic features, and proved very attractive.

The Queensland Merinoes vary considerably, but strong and fine types are well represented. The qualities differ greatly; some wool, for instance, grown in the southern portions of the State in which there is an infusion of Tasmanian blood, is excellent and spins well; but other wools, though of good appearance, lack character and strength, possibly through lack of sufficient nourishment. The flocks reared in the more central and northern districts are of this latter type, and their wool is usually dry, open, and somewhat wasty. These wools scour readily, giving a colour which is all that can be desired. A considerable portion of this clip is taken by the woollen and hosiery trades. Of late the seasons have been good and a marked improvement in the flocks has taken place, due to careful selection for breeding purposes.

Western Australia is chiefly noted for its Swan River wool. The conditions for rearing sheep in this State are very varied, but, upon the whole, are inferior to those of other States. The strong type of Merino is most in evidence, being best suited to the typical conditions. The wool is of good length, but it is dry in handle, and contains enormous quantities of red earthy impurity. Wool-producing in this country has not yet reached its final development, for the sheep are not so well bred, nor is the wool so satisfactorily marketed as is the case elsewhere. Marked progress, however, is being made.

Tasmania produces wool second to none. The fine Merino is the sheep principally reared, yielding wool which for length, fineness, softness, density, and milling power cannot be surpassed (an example is given

in No. 2, Fig. 30). The wool is grown under most suitable conditions, and is the object of unremitting care on the part of the producer, who, as a rule, owns only a small flock. This wool is useful for the highest class combing and clothing purposes. Its "yield" (clean wool from scouring) is excellent.

New Zealand accounts for a very small number of Merinoes, 10 per cent. only of the total flocks being of that type. A strong Merino sheep, yielding long, strong, but soft wool, is most in evidence. These wools are rich in yolk, but upon the whole they "yield" satisfactorily. They spin well, and are principally employed for worsteds.

Cross-bred wools.—Cross-bred wools owe their marked dominance largely to the development of the frozen mutton trade. Large-bodied sheep are bred for this trade, and it follows, in consequence, that the wool is of a coarser character than that yielded by the small Merino. This, of course, is entirely a matter of the profit to be made, of which an estimate is as follows:—

Cross-bred			
Carcass, worth, say . . .	£1	1	0
Wool, worth, say . . .	0	12	0
Total . . .	£1	13	0
Merino			
Carcass worth nothing . .	£0	0	0
Wool, worth, say . . .	0	8	0
Total . . .	£0	8	0

Another factor of importance is this: that as the land is developed, it becomes more suitable for the pasturing of cross-breds. The competition in fine wools

due to the expansion of this trade in South America and the Cape, may also partially explain the tendency to grow cross-bred at the expense of Merino wool.

In some few cases there can be no doubt but that a stronger sheep than the Merino is suited to the more exposed climatic conditions.

In Australia about 75 per cent. Merino to 25 per cent. cross-bred wool is grown, and the tendency is for the cross-bred proportion to increase slightly. In New Zealand the tendency is for cross-breds to supplant Merinoes altogether, largely because both soil and climate favour this. Twenty years ago the proportion was 25 per cent. cross-bred to 75 per cent. Merino; in ten years it had grown to 90 per cent. cross-bred and 10 per cent. Merino, and to-day the quantity of Merino is only 5 per cent. of the total growth. For Australasia and River Plate the combined proportion is about 47 per cent. cross-bred, to which amount it has dropped from 52 per cent. in 1904. This reduction, however, may be only a fluctuation due to the swerve of fashion favouring fine wools. Up to 1904 there had been a marked increase in the cross-bred percentage for about ten years.

Types of Cross-breds.—These may well be considered under two heads: (1) There is the true half-bred type, which is produced by crossing two distinct breeds of sheep, usually a long wool and a Merino breed. (2) There is a type variously known as quarter-bred and come-back (in the U.S.A. spoken of as "three-quarters blood," etc.), produced by subsequently recrossing the half-breds back towards the Merino. These types are well represented in the diagram on the next page:

It will thus be evident that complete ranges of

wool qualities may be produced, varying from the half-bred towards either the long-wool sire or the short-wool dam.

Breeds Employed as Crosses.—Most English breeds have been crossed with the Merino, but a few only

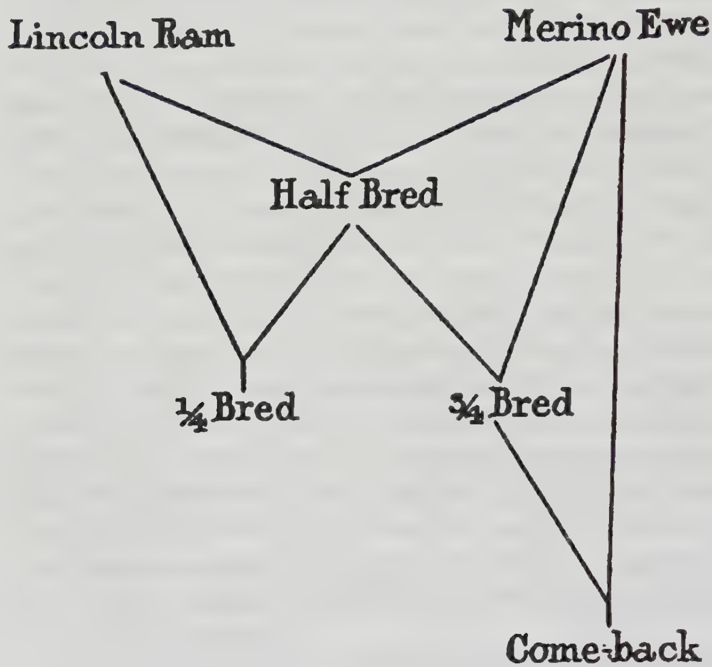


Fig. 31.

have become popular. Of these the Lincoln, Leicester, and Border-Leicester are the most popular of the long-wool class, and the Shropshire and Southdown of the short-wool class. Possibly this latter class owes its popularity to the fact that two lambing seasons may be got into one year, and that the mutton produced is of a superior quality.

It will thus be evident that there are two types of

DIFFERENCES BETWEEN TYPICAL EXAMPLES OF CROSS-BRED WOOLS

Type	*Quality*	*Length*	*Strength*	*Colour or Lustre*	*Fineness*	*Softness*
Lincoln-Merino	40's	9 in.	Strong	Yellowish, very lustrous	1-600th in.	Fairly soft
Shropshire-Merino	50's	4½ in.	Fairly strong	White	1-800th in.	Fairly soft

Type	*Elasticity*	*Waviness*	*Appearance*	*Shrinkage*	*Uses*
Lincoln-Merino	Elastic	Slightly wavy in fibre	Tapering staple	30 %	Demi-lustre fabrics, and as blended with pure English for lustre fabrics
Shropshire-Merino	Weak	10 crimps per in.	Fairly uniform in thickness	45 %	Fine serges and hosieries and a substitute for Botanies

cross-bred wools—namely, the Lustre × Merino and the Down × Merino. The list on p. 65 indicates the differences between typical examples of these two classes, while the variation in appearance of the low, medium and fine types is shown in Fig. 32.

Cross-bred Types Produced in the Various States.—In New South Wales cross-bred wool is being grown in increasing quantity, particularly in the eastern and south-eastern portions of the State, On the richer lands the Lustre-Merino cross is favoured, and on the other lands the Down-Merino cross is most popular. Upon the whole, the Lincoln cross is mostly in evidence, as the mutton produced is of equal importance to the wool grown. Leicesters and Border-Leicesters, however, are employed to a certain extent. Of the Down breeds the Shropshire is the favourite, as it produces an early maturing lamb and a useful wool. These cross-bred wools, as grown in New South Wales, are very valuable. They spin well and yield fabrics of very desirable characteristics.

Victorian cross-breds, however, are as superior as Victorian Merinoes. In this case the Leicester and Shropshire crosses have been most successful. The wool is deep and dense in staple, has a bright and uniform fibre, with marked Merino characteristics, and is of first-class spinning capacity. A wide range of qualities is produced, from a typical cross-bred to a 58's come-back wool.

South Australia is not really of much importance as regards cross-breds; but Shropshire-Merino crosses are receiving increasing attention and producing a useful type of wool of a sound and medium-fibred character.

In Queensland little attention up to the present has been given to cross-bred wools. Shropshire crosses

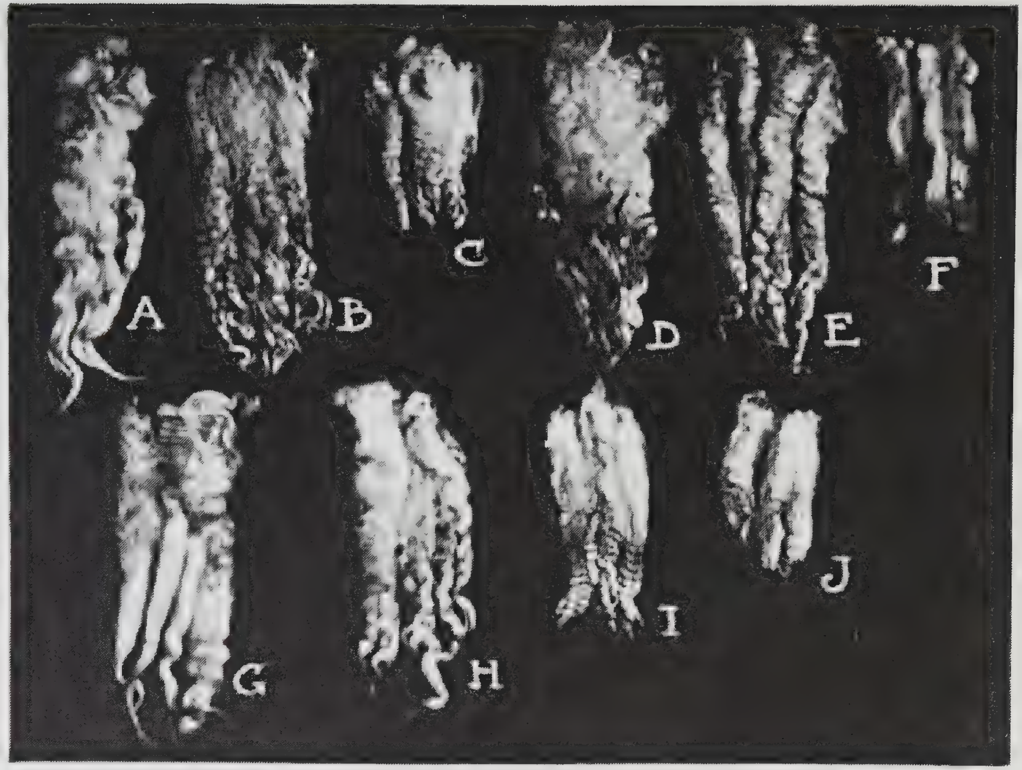


Fig. 32.—Quality Range of Cross-Bred Wools

New Zealand Cross-Breds—A, 32's; B, 40's; C, 56's. Australian Cross-Breds—D, 32's; E, 40's; F, 50's. South American (B.A.) Cross-Breds—G, 40's; H. 46's.; I 50's; J, 56's.

have been introduced, but chiefly from the mutton point of view. For crossing with the Shropshire a robust, well-woolled Merino sheep is desirable, or the inherent weakness of the Shropshire wool, due to the chalkiness of its native soil, is transmitted to the progeny. Thus the more northerly grown Queensland Merino sheep, yielding a wool staple of only moderate strength, is not suited for crossing with the Shropshire.

In Western Australia only a few fine cross-bred sheep are grown. In Tasmania fine cross-bred wools of the true type, with a tendency towards the come-back, are produced. These wools occupy a foremost position among cross-breds, being of a strong, shafty, and uniform staple, and of good colour.

New Zealand is the greatest cross-bred colony of Australasia, the types of cross-breds here grown being unrivalled in strength, soundness, fineness, softness, lustre, and colour. An enormous range of qualities is produced, owing to the many types of sheep employed and to the various degrees of crossing. These wools are extremely yolky and, consequently, are well nourished and sound.

Colonial Pure-bred Wools.—Pure-bred English sheep are not uncommon in the Colonies. Unfortunately, the Lustre breeds to a certain extent lose their lustre and tend to become shorter; but they are improved in fineness, softness, and flexibility, and, as a result, are much sought after. They are chiefly grown in Victoria, but are invariably known as cross-bred wools.

The Romney Marsh sheep is to be found in New South Wales, Victoria, and New Zealand, its hardihood in withstanding foot-rot and fluke specially fitting it for much low-lying land rich in herbage, but possibly

with little natural drainage. It is a useful mutton producer, and the Colonial grown wool is soft and full and of satisfactory length, strength, and fineness, ranging from 46's to 50's quality. In New Zealand not only is it crossed with Merino, but also with the Lincoln and Leicester breeds.

The Wools of Cape Colony.—Cape Colony and Natal are essentially fine wool producing countries. Sheep farming is here a very old industry, the pastoralists being among the pioneers of fine wool growing. The country, upon the whole, is not so suitable as Australasia for sheep rearing, the natural vegetation being a shrub (*karoo*) which grows more or less in dirty sand, and as a consequence the wool is dirty and yields badly. Until recently little attention has been devoted to the development of the Merino breed, and the wools produced have been very negligently prepared for the market. Double clipping is often in evidence, causing the wool to be suitable only for weft and hosiery yarns, while bad skirting and pressing, and even dishonest packing, are sometimes in evidence. Of late earnest endeavours have been made to improve the Cape flocks. The best Australian stud rams have been introduced, and the reorganisation of the flocks definitely taken in hand.

Cape wool is very fine and silky, but usually short and of "clothing" quality, yielding from 60's to 70's quality (Nos. 3 and 5, Fig. 30). The yield of pure wool is often as low as 30 per cent., but the wool scours readily and is of perfect whiteness when thoroughly cleansed. Thus Cape noil is worth ½d. per pound more than Australian noil, simply on this account. The fibre is lean in appearance and handle and is not generally strong, but it suits the clean-faced, slippery handling

cloth into which it is made, this being an acknowledged trade line. The German worsted spinners use considerable quantities of the wool for lace-making purposes. In Bradford it is often blended with ordinary or average Australian, or even B.A. wools, for the purpose of bringing up the quality. As a milling material it is very unsatisfactory. Owing to the demand for fine Merino wools there is undoubtedly a future for Cape Colony and Natal if the flocks are developed on right lines.

South American Wools and their Uses.—South American wools are chiefly produced in the Argentine Republic, Uruguay, Punta Arenas (in Chili), and the Falkland Islands. Argentine wool is known as B.A. (Buenos Ayres) or River Plate. Uruguayan is known as M.V. (Monte Videan). In each case the name is taken from the chief port at which selling and shipment take place. Punta Arenas and Falkland Island wools retain the names of the places where they are grown.

The vegetation and the climatic conditions of South America naturally vary very considerably; but in most cases they are very suitable for sheep rearing. Tremendous flocks are carried; thus in 1907–8 South America accounted for over 90 million sheep. In the past, cattle and grain, being more valuable, obtained more attention than wool; this latter commodity, therefore, has deteriorated and is weak and wasty, owing to bad growing; it has, moreover, been badly marketed. During the past few years, however, most marked improvements have been introduced. Thus in 1906, £160,000 was paid to British breeders for the best stud sheep, and wool-buyers' requirements have been much more carefully studied. Unfortunately, the

natural herbage is very burry and seedy, and, as a consequence, these wools are liable to contain a large percentage of vegetable matter.

South American Merinoes.—The Merinoes of South America were originally developed from the Spanish type with the Vermont Merino introduced later. M.V. wools are very largely of the Merino type, varying from 58's to 64's in quality (*see* No. 4, Fig. 30 for an example of 60's to 64's quality). They yield well, being short and loose in staple, are full and spongy to the handle, and most suitable for hosiery and dress fabrics of a soft character. They are also used for blending purposes with Australian wools to cheapen the resultant top. At one time there was a distinct prejudice against these wools in this country. To-day they are largely used both here and on the Continent; in the latter case they are often treated unblended on the dry-combed principle. These, in their pure state, cannot be spun on the Bradford machinery to very fine counts, and are indifferent milling wools.

South American Cross-breds.—Both the Lustre-Merino and Down-Merino crosses are in evidence. There are, naturally, wide ranges of qualities, but the wools in all cases are broader stapled, shorter, lighter and fuller in fibre than the Australian types. A range of these qualities is shown in G to J, Fig. 32. Thus a B.A. top is about half the weight of a New Zealand top of the same size, being lighter fibred, spongier, and more springy. For worsted cross-bred styles they are more economical than Australian or New Zealand cross-breds, and as they are short and springy they give more body to the fabric than the latter; but great care must be taken in the finishing processes as applied to the fabrics into which they are made.

Punta Arenas wools have latterly markedly increased in favour. They are exceptionally light, blobby, and springy, and are in great demand for hosiery and soft dress goods. They are of the Down-Merino type, 4 to 5 inches long, yielding well, and producing a top of from 50's to 56's quality.

As Falkland Island wools are largely grown by Scotchmen they are, naturally, of the Cheviot or Cheviot-Merino type. The qualities are generally somewhat lower than the Punta wools, say 46's to 50's.

Skin and Slipe Wools.—Since the development of the frozen mutton trade, the trade in skin and slipe wools has markedly developed. The skins of slaughtered sheep may be dealt with locally; but, at least in the case of Australia, New Zealand, and South America—countries which control the bulk trade—sheepskins are dealt with from special centres, of which Mazamet, in France, is the most noted.

The methods by which the skins are "de-wooled" give their names to the wool taken off. Thus, if the wool is simply "sweated off"—the method most largely employed in Mazamet—the wool is termed "skin-wool." If the older and, until quite recently, the more frequently employed method of de-wooling the skins by means of lime has been used, then the wool is spoken of as "slipe." If sulphide of sodium has been employed, the wool is usually recognised as a "Colonial skin wool."

The "sweating method" depends for its efficiency upon the development of bacterial action, probably with ammonia as a secondary product, within the skin, resulting in the destruction of the soft connecting tissue between the cuticle, or outer skin, and the corium,

or true skin, and also of the soft bulbous root of the wool fibre.

The "lime method" depends for its efficiency upon the dissolving of the cuticle and the soft gelatinous matter in the skin by the lime employed. In this case the agent acts from the wool side of the fleece invariably, and owing to its dissolving properties partially dissolves useful portions of both the wool and the skin.

The "sulphide method" depends for its efficiency upon the wonderful power possessed by the agent used in dissolving the wool fibre and the closely allied cuticle. On the other hand sodium sulphide improves the corium or skin proper, and, consequently, may be applied to the inside of the skin, acting from within outwards. It is obviously most desirable that the sulphide or other agent employed should be kept from the wool, as it very rapidly disintegrates it. As the wool may be "pulled" before the action of the sulphide has penetrated to the outside, the "wool-pit," or portion of the cuticle surrounding the fibre, will frequently be pulled away with it.

There is one other method of de-woolling skins, and that is by burning off with an electrically heated platinum wire. This is claimed to leave the skins more intact and to yield wool equal to sheared wool, save for the burnt ends. Up to the present this method has only found a very limited employment.

With reference to the quality of skin wools, this obviously depends in the first place upon the different natures of wool clipped from the live animal and taken from the dead skin. The argument is that as wool or hair grows upon a dead body or skin, there is no difference. Some hold, however, that there is a difference —that skin wool has lost some of its nature; while, on the other hand, the fact must not be lost sight of that

the Shetland people "roo," or pull the wool from the living sheep, believing that in this form the wool is softer. It is thus evident that each parcel of skin or slipe wool must be judged on its merits. Upon the whole, "skin wools" yield better than would naturally be expected; but slipes must obviously be regarded with suspicion, as scouring difficulties will arise according to the amount of free lime present.

The Various Hairs and their Uses.—**Turkey Mohair.**—To-day this hair is not of the quality it once was. Formerly it was brilliant, lustrous, and of remarkable length and fineness, being grown under ideal conditions—that is, in a dry climate with rich aromatic herbage and much natural shelter afforded by large forests. The deterioration noted has, no doubt, been brought about by crossing on the common Kurd goat, for the latter only yields a long, coarse, and kempy hair, ordinarily used for tent and sackcloth. This deterioration took place principally from 1820 to 1860, the result of an unexampled demand on the part of Europe for this fibre, possibly brought about by the introduction of mechanical spinning. A cessation of the demand about the year 1880 resulted in discontinuation of this crossing to a very great extent, the breeding back to the true Angora type taking its place. Still, the modern Angora goat is not so satisfactory in fleece as the original goat, but owing to the Kurd influence it possesses a very strong constitution. Still Turkey mohair, compared with the mohair of other countries, is of the very best, being of excellent length, of superior lustre, of a clear colour, and in weight of fleece very satisfactory.

The mohair area in Turkey is from 60,000 to 80,000 square miles, in the provinces of Angora and Kasta-

monni. This area is divided into goat districts, considerable divergence of type being noticeable in these. The following list gives an idea of the variations which may be expected. The views of the actual material in Fig. 33 should also be consulted.

	Turkey Fine	*Turkey Fair Average*	*Turkey Beybazar*	*Turkey Kastamboul* *
Length .	6 in. to 7 in.	6 in. to 8 in. .	$7\frac{1}{2}$ in. to 9 in.	8 in. to 10 in.
Lustre . .	Very lustrous	Fairly lustrous	Lustrous .	Very lustrous
Fineness .	1·800 . .	1·400 . . .	1·600 . .	1·600
Handle .	Very soft .	Fairly soft .	Soft . .	Very soft
Appearance	Good colour, wavy, clearly defined	Fair colour, not clearly defined in staple	Good colour, clearly defined in staple	Good colour, wavy, clearly defined in staple
Cleanness .	Very clean	Fairly clean .	Fairly clean	Clean
Uniformity	Very uniform	Uniform . .	Uniform .	Uniform

* In addition to these there are lower qualities, such as "good yellow" and "good locks."

Great improvement could be made in the growth of Turkey mohair if the ignorance and superstition of the growers could be overcome. Breeding is still conducted on the crudest lines, while a lack of cleanliness, and the absence of sorting or classing and the prevalence of dishonest packing all militate against the development of the industry. In fact, reform is desirable from both the producer's and the user's standpoint. The proportion and quality of hair yielded by Turkey is a very strong factor in the trade, and with the increased railway facilities promised in the near future it is to be hoped that the Turkish grower will endeavour to bring himself more into line with the user's requirements, to the ultimate benefit of both.

Cape Mohair.—The difficulties experienced in establishing flocks of the Angora goat in Cape Colony were

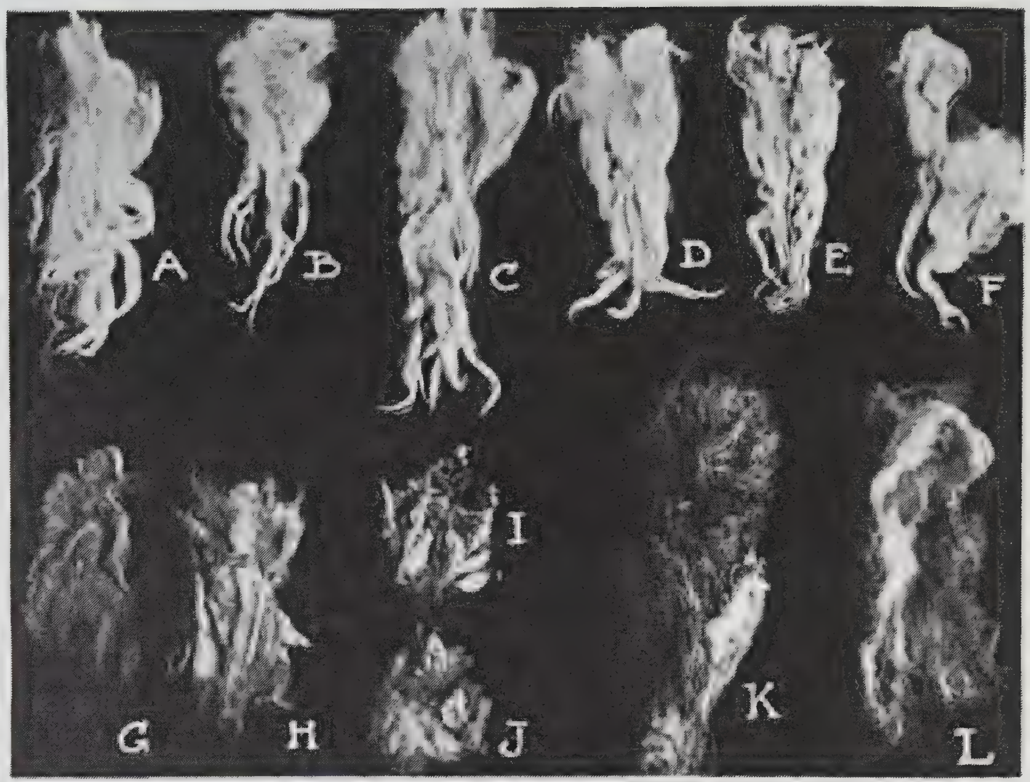


Fig. 33.—Types of Hair.

1. Mohair—A, Fair Average Turkey; B, Good Turkey; C, Cape Long Blue Firsts; D, Cape Somerset Firsts; E, Cape Summer Firsts (eight months' growth); F, Cape Winter (four months' growth). *2. Alpaca*—G, Low Arequipa Alpaca; H, Fine Arequipa Alpaca. *3. Cashmere*—I, Seconds Cashmere; J, Firsts Cashmere. *4. Camel's Hair*—K, China Thirds; L, China Firsts.

very great, as it was necessary to cross the Angora with the common South African goat on similar lines to those described with reference to Turkish flocks; and the progeny of this cross required much attention and considerable time to bring up to the condition in which a reasonable standard of mohair was yielded. Evidences of this first crossing are even now to be seen in some types, but great improvement has been effected, and to-day large quantities of African mohair equal in many respects to Turkey mohair are produced. It is thus evident that Cape Colony provides suitable conditions for the development of the Angora goat, and it is most satisfactory to note that to-day the flocks total up to four million goats, yielding half the world's supply of mohair. If, however, the best is to be made of the possibilities of development the following matters require attention. Firstly, if possible the necessity for double clipping must be avoided. Clipping the goat twice during the year—summer and winter—necessarily implies a short staple, and although occasionally the winter growth (short) has brought a higher price than the summer growth (long), still, as a general rule, the condition obtained that the longer the staple and the more lustrous the yarn into which it is spun, the more valuable it is. If, as is sometimes stated, double clipping is necessary to prevent the shedding of the fleece, then it is obvious that this improvement cannot be looked for. The greater proportion of waste in dealing with the shorter mohair is also a factor which should be taken into account.

Secondly, the fineness of the fibre is not all that can be desired, and the proportion of kempy mohair is too great. Fineness can obviously most readily be developed by careful breeding, while the elimination of kemps may also be effected in a similar manner.

Thirdly, uniformity in staple is too often conspicuous by its absence; the fibres are thick and long, while at the bottom of the staple there is too much short fibre.

Fourthly, bad classification is too much in evidence, there being many mixed bales in which are to be found untrimmed and dirty pieces. The baling itself also leaves much to be desired.

In the list on page 77 a fairly complete range of Cape mohairs are included, from which it will be noted that Cape kid and Cape firsts are valuable products, the former being remarkable for fineness and the latter for length. Unfortunately, the amount of these is small.

U.S.A. Mohair.—On the North American continent the Angora goat is chiefly cultivated in California. It is highly valued as a scrub clearer. Most of the yield is at once consumed by the home manufacturer. These flocks have been built up partly by means of a cross with the native Kurd goat, but many more pure Turkey Angoras were imported than was the case in Cape Colony. The quantity grown is comparatively small, say 1½ million pounds per annum from about 800,000 goats.

Australian Mohair.—This industry is in its infancy, there being probably only some 30,000 goats in New South Wales and a similar number in Queensland. It seems probable that these numbers will be improved upon, but the development is likely to be slow, as Australia is essentially a wool country, and the Angora goat is only likely to be useful where scrub requires keeping down. The staple is said to be equal to average Turkey mohair, and is favourably reported upon by users.

Special Qualities and Uses of Mohair.—The fibre is harder, stiffer, and yet more elastic than wool, a special feature being that it is impossible to tie a knot on the

RANGE OF CAPE MOHAIRS

Type	*Length*	*Lustre*	*Fineness*	*Handle*	*Appearance*	*Cleanness*	*Uniformity*
CAPE KID .	5 to 7 in	Very lustrous	1·800 in.	Very soft	Yellowish colour, clearly defined staple	Clean	Very uniform
CAPE FIRSTS .	6 to 8 in.	Very lustrous	1·600 in.	Soft	Fair colour, clearly defined staple	Fairly clean	Fairly uniform
CAPE WINTER	5 in.	Fairly lustrous	1·600 in.	Fairly soft	Fair colour, fairly defined staple	Fairly clean	Fairly uniform
CAPE SECONDS	5 in.	Fairly lustrous	1·600 in.	Fairly soft	Bluish colour, kempy, fairly defined staple	Dirty	Not uniform
CAPE MIXED	4 to 5 in.	Poor in lustre	Irregular —coarse	Harsh	Varied; disorganised in staple; strong and "wiry"	Dirty	Not uniform

staple. The physical qualities of the fibre render it the most suitable for permanence of embossing in upholsteries, and for strength of pile as developed in pile fabrics. It is most lustrous, in this respect rivalling silk, and, better still, permanently retains this quality. Except in the case of kempy fleeces the fibre is never weak, and thus valuable fabrics, as regards strength, may be made from it. Its absorption of moisture is less than that of wool, but it is indifferent to felting, and therefore must be used for such fabrics as require little milling. Its draping properties are excellent, as instanced in the many beautiful lustre goods produced in the Bradford district. One special use of mohair is for braids, for which there is a large trade.

Alpaca and its Uses.—The ordinary Alpaca clip yields a length of, say, 9 inches, but much is allowed to grow for two or even three years, when it reaches 30 inches in length. This, however, is liable to cause weakness in the fibre staples, resulting in wastiness in the manufacture. Various qualities are available, three divisions, as a rule, being made, namely "low," "medium," and "fine." Alpaca is known as Arequipa Fleece, Arequipa being the Peruvian port from which it is shipped. It is specially used for dress goods, linings, and facings for overcoats.

Camel-hair and its Uses.—True camel's hair is a fine, downy material, about 5 inches long, of a yellowish or brownish shade. Long, strong fibres are invariably found with this, which come from the under-parts of the camel; these must be combed out. There are many types of camel-hair—Chinese, Persian, Russian, etc., but all are classed as firsts, seconds, or thirds, the firsts being freer from coarse fibres and more uniform, and so on. True camel-hair is not strong, as it seems to lack

nature. It thus needs careful treatment or waste will be excessive.

The fine fibre is employed for dress fabrics and linings; while the coarse, which is exceptionally strong, is used for beltings and stout fabrics.

Cashmere and its Uses.—As the Cashmere goat is not bred in great numbers, and as each goat yields only a small weight of true cashmere, the total weight of cashmere available is very small. The best cashmere is recovered as noil in the combing operation. The length is from 2 to 3 inches, and the qualities are classed as "first" and "seconds," brown or white. As the fibre is very light and fluffy, it needs much care, and must be suitably controlled in the spinning. It is used for shawls, dress fabrics, and hosieries of soft handle and light weight characteristics.

On p. 80 is a comparative list of the various hairs, which should be studied in conjunction with Fig. 33.

Re-manufactured Materials.—These materials are of remarkable importance to the woollen trade. A hundred years ago fibre once spun into yarn and woven into cloth could not be used again even for the production of inferior materials. To-day there is a huge industry largely located in the Dewsbury, Batley, and Ossett districts of Yorkshire, based entirely upon the production of fabrics from materials which have already played a part as fabrics. Thus, these materials find employment as wefts in cotton warp goods, as backing material in the worsted trade, and as material to mix with wool, cotton, etc., in the woollen trade. It is true that these materials have neither the character nor durability of the true wool fibre. Nevertheless, they are re-manufactured into fabrics, which,

COMPARISON OF HAIRS

Type	*Length*	*Strength*	*Lustre*	*Colour*	*Fineness*
Mohair	9 in.	Very strong	Very very lustrous	White	1·700 in.
Alpaca	12 in.	Fairly strong	Very lustrous	Vari-coloured	1·800 in.
Camel's Hair	5 in.	Fairly strong	Lustrous	Brown and yellowish grey	1·800 in.
Cashmere	3 in.	Fairly strong	Lustrous	Brown and white	1·1200 in.

Type	*Handle*	*Form of Staple*	*Uniformity: (1) in thickness, (2) in length*	*Uses*
Mohair	Fairly soft	Straight-fibred; wavy in staple	Uniform	Dress fabrics, linings, and upholsteries
Alpaca	Soft	Straight-fibred; staple disorganised	Uniform	Dress fabrics and linings
Camel's Hair	Soft	Fairly curly, staple disorganised; thick hair present	Fairly uniform	Dress fabrics
Cashmere	Very soft	Fairly curly, staple disorganised; thick fibre present	Fairly uniform	Shawls and hosieries

considering the price at which they are placed on the market, are truly wonderful.

The principal re-manufactured materials are noil, mungo, shoddy, extract, and flocks.

Noil.—Noil is the short material removed from the wool during the operation of combing. There are several classes which take their origin in the wools from which they are combed. These classes, briefly, are: English (Lustre), Cross-bred, Botany, and Hair Noils. The length of noil varies from about 2 inches in the case of hair noils to under ½ inch in the case of short botany noils. Owing to their shortness, noils are only suitable for use in the production of woollen yarns and for felting purposes. As will naturally be expected, vegetable impurity is often present; this is removed prior to carding by carbonisation on the chemical principle.

Botany noil is the most valuable, and is placed on the market in various qualities, such as 60's, 64's, and 70's. It is fine in fibre and generally whitish in colour, varying in length from ¾ to ¼ inch. This noil is of excellent milling property, but, as a rule, is very burry. Cape noil of this class is the most valuable because of its superior colour. This noil is employed in woollens, shawls, blankets, and hats. There is a considerable trade done at Bradford in the purchase of noils from the combers, forwarding them to commission carbonising and carding firms, and afterwards selling them into the Leeds, Batley, and Dewsbury districts, also to the Cheshire hat manufacturers, and to Continental woollen spinners.

Cross-bred and English noils are of lower quality than Botany noils, the fibre being longer, smoother, and stiffer, and of less satisfactory spinning capacity. As a rule, the lustre is good, but the colour is of a

yellowish cast and the milling capacity poor. Vegetable matter is often present in the form of burrs in Australian, New Zealand, and South American wool noils, which must be removed by carbonising, a process which leaves the fibre harsher still in handle. The best qualities of noils are used in the hatting trade, for blankets, and for fine woollens. The lower qualities are blended with mungo, shoddy, etc., for low woollens, and are also used in carpets, their brightness here being a valuable characteristic.

Mohair noils, owing to double and treble combing (with the idea of producing an absolutely uniform top), are frequently so long as to warrant a short top being made from them. These noils are bright and lustrous, soft, and silky, but have neither milling capacity nor marked spinning capacity. They are used in their softer and finer form with other re-manufactured materials in cheap woollens, and they are also made into carpet yarns. Others are used as stuffing for mattresses.

Mungo.—Mungo results from the grinding into a fibrous condition of hard worsted and woollen cloth rags and clippings. The quality varies from medium to fine, but owing to the cloths from which it is made being firmly built it naturally follows that there is considerable breakage of fibre in the grinding process, and, as a result, the mungo produced is not suitable for the finest woollen spinning. The colour naturally varies in accordance with the materials from which the mungo is produced, advantage being taken of this in producing both solid and mixture "natural" shades. The milling capacity is frequently quite satisfactory.

There are two types of mungo—namely, the "new" and the "old," taking their title from the fabrics from which they are produced, the new being naturally the

most valuable. Both these materials are made into very cheap fabrics, being blended with wool, cotton, etc., for the production of yarns on the woollen principle.

Shoddy.—This, in a sense, is only another name for mungo; but it is usual to refer to the material produced from soft goods, such as stockings, etc., made in the first instance from the longer wools, as "shoddy." Upon the whole, the shoddy fibre is longer and coarser than the mungo fibre. It is usual to make various qualities and colours, and also to produce shoddy from new and old rags. The milling properties of this material are indifferent, as it partakes, of course, of the qualities of the original material from which the shoddy is derived. Its uses are similar to those of mungo, but the resultant fabrics are naturally of a somewhat coarser character. They are also cheaper.

Processes in the Production of Shoddy and Mungo.—The processes to which rags are submitted which are to be made into shoddy and mungo are, first, dusting; second, sorting; third, seaming; fourth, oiling and grinding.

Dusting is necessary to free the rags from deleterious impurities. If necessary, the rags must be disinfected, but it is curious to note there is no recorded case of any disease having been conveyed by rags.

Sorting of the various colours of rags is undertaken to enable standard mixture colours to be produced without the necessity for stripping and re-dyeing.

Seaming is done with the idea of extracting every bit of hard cotton thread from the material, for if such are left in it they cause breakage of the yarn during the spinning operation.

Oiling and grinding consist, first, in lubricating the rags to prevent, as far as may be, fibre breakage, and

secondly in a teazing out of these rags, fibre by fibre, until the whole of the rags are reduced to a fibrous mass.

The following description of a grinding machine will render the process of grinding easy of comprehension.

A large cylinder is employed round which are working a series of small cylinders, both large and small cylinders being clothed with "garnett" wire or blades with saw-like edges. The direction in which the teeth of these various rollers work, and the speed and the closeness of their setting in regard to each other, are such that when the tightly constructed material is fed up to them it is first torn strand from strand and afterwards teased out fibre from fibre with comparatively little breakage, and the various movements of the rollers yielding this are also instrumental in carrying the material through the machine and delivering it in the form of a broad open web of wool. Further particulars of this machine will be found in the section dealing with woollens.

Extract.—Extract is a type of material similar to shoddy or mungo, but it takes its name from the fact that it is made from wool which has been extracted from a cotton and wool cloth by a process of carbonisation, or "extracting," as it is termed. Thus fabrics made of, say, cotton warp and worsted weft are first subjected to a carbonising treatment, by means of which the cotton is pulverised, leaving the worsted weft more or less unaffected. This worsted weft is then ground up into a fibrous mass which receives the name of "extract." This material is, naturally, harsh in handle, owing to its having passed through the carbonising process; in other respects, it largely partakes of the characteristics naturally to be expected in the material from which it is originally produced. It is

COMPARISON OF RE-MANUFACTURED MATERIALS

Material	*Sources*	*Colour and Lustre*	*Fineness*	*Length*	*Handle*	*Appearance*
NOIL .	Combed wool	Vari - coloured; the longer noils lustrous	1·400—1·1500 in.	½—2½ in.	Fairly soft (long noils) and very soft (short noils)	Open and flakey
MUNGO .	"Hard" Woollen and Worsted cloths	Vari - coloured, non-lustrous	1·800—1·1800 in.	¼—¾ in.	Soft and very soft	Partially matted and thready
SHODDY	"Soft" knitted goods	Vari - coloured, lustrous	1·600—1·1200 in.	½—2 in.	Soft	Fairly open and fluffy
EXTRACT	"Hard" "Union" Goods	Vari - coloured, not very lustrous	1·800—1·1500 in.	¼—¾ in.	Harsh	Partially matted and thready
FLOCKS .	Worsted Goods	Vari - coloured, sometimes lustrous	1·400—1·1500 in.	¼—¾ in.	Fairly soft	Curly and fluffy

used in the low woollen and tweed trade, being, as a rule, blended with better materials.

Flocks.—There are two kinds of flocks, namely, finishers' flocks, and flocks produced from carbonised burr waste. The finishing flocks are produced in the milling, shearing, and raising processes, and as a consequence are always short in fibre; they vary also in quality according to the fabrics from which they are produced. The burr waste mentioned is also of short length, and only of fair milling and spinning capacity. The best flocks are used for blending materials in the production of the better low-class woollens and tweeds. They are also used as a filling material for certain fabrics, being employed during the process of milling. In the case of the lowest class of all this is used for embossed wall-papers.

A comparative list of the re-manufactured materials will be found on p. 85.

GROWERS' AND USERS' TERMS

Ram: A male sheep.

Ewe: A female sheep. Ewes' wool is finer than that of rams of a corresponding breed.

Lamb: Applied to sheep from time of birth to time of weaning, say until seven months old. Lamb's wool is glossy and slippery, difficult to comb and spin.

Hog (or Hogget): Given to sheep from time of weaning to that of the first fleece being shorn. "Hogs' wool" is applied to first full fleece. The point of the wool tapers; if the staple be drawn, both this and the neighbouring ones are disarranged. Such wool is finer and brighter than subsequent clips.

Wether: Wool of second and succeeding fleeces. The staple ends are blunt, and the staple can be drawn out cleanly.

Tup: A term originally of Scotch application, given to male sheep. Much used in Yorkshire.

CHAPTER IV

COMMERCE IN WOOLS AND HAIRS

History of the Commerce in English and Irish Wools.—This subject has been treated at great length by writers such as Luccock, Youatt, Bischoff, James, and others, and more recently has claimed the attention of Mr. J. H. Clapham, who at the time he published his work on "The Woollen and Worsted Industries" was Professor of Industrial Economics in the University of Leeds; thus, as he was right in the heart of the wool industry and, further, was able to turn up certain Government Blue Books, he was able to produce a work of the utmost value. The following brief notes are therefore all that are called for here.

Britain was renowned for wool from the earliest times, and it seems probable that the oldest breed was a short wool, which was employed in the first English factory at Winchester. Long wools were no doubt produced as the demand for the quality of length increased, and so well was the demand met that the wool trade of England developed to very great proportions. Thus, prior to 1870, it may be said that prices were good and the industry prosperous, this especially being the case with reference to long wools. Of late, however, the development of the Colonial trade has had a marked influence upon English wool as a raw product. This is well illustrated in Fig. 6 on p. 12, in

which the production of English wool from 1800 to 1908 is shown graphically. In fact, it may usefully be considered that now, instead of dealing in English wool, the dealing is in English sheep, which, transported to other congenial climes, naturally result in the production of wool which competes seriously with the English clip.

MOVEMENT OF WOOLS FROM WOOL-GROWING CENTRES TO MANUFACTURING CENTRES

The wool-growing centres are the Home Counties of England, Australasia, the Cape, South America, Continental, and some few other foreign countries. In each case some special procedure is adopted. Thus, for instance, while wool grown on the Australasian coast may be washed, it is obvious that such can rarely be the case with wools grown up country, where there is a shortage of water. A few notes on the procedure in each case will here prove useful.

A. **Home Grown Wools.**—With these buying is usually done direct from the farmer by the wool stapler, or the wool may be bought at the local fairs, of which a list will be found on the next page. Under these conditions the terms are cash, the buyer provides his own sheets, and the wool is weighed by the pound or, more usually, by the tod of 28 pounds. In Ireland there is a good deal of interchange of commodities, the storekeeper often advancing stores in return for wool, and thus acting as a "go-between" for the wool-producer and the wool-user.

If wool is bought direct from the wool-grower it is collected by the railway company's wagons and forwarded by rail to the manufacturing centre. If bought at an auction sale, the wool is also taken charge of by

LIST OF BRITISH WOOL SALES AND FAIRS

June	Leith
	Market Drayton
	Wellington (Salop)
	Colchester
	Shrewsbury
	Oswestry
	Nottingham
	Ipswich
	Lichfield
	Sleaford
	Bury St. Edmunds
	Loughborough
	Leicester
	Glasgow
	Huntingdon
	Rugby
	Wellingboro'
	Northampton
	Melton Mowbray
July	Gloucester
	Cirencester
	Guildford
	Stratford-on-Avon
	Reading
	Blandford
	Andover
	Dorchester
	Leith
	Alton
	Basingstoke
	Chichester
July	Birmingham
	Winchester
	Newport (I. of W.)
	Swindon
	Wantage
	Perth
	Salisbury
	Hungerford
	Newbury
	Wallingford
	Didcot
	London (commences)
	Devizes
	Aylesbury
	Marlborough
	Henley-on-Thames
	Lewes
	Ipswich
	St. Boswell's
	Liverpool (commences)
	Glasgow
	Milnathort
Aug.	Kelso
	Leith
	Perth
Sept.	Glasgow
	Bristol
	Liverpool (commences)
	London ,,
Nov.	Liverpool ,,
	London ,,

the railway company's representative and forwarded to the stapler's order.

B. **Colonial Wool.—Australasian.**—Until recent years buying and selling was usually carried on in London, but to-day a considerable business is done at the various centres of production, and the tendency is undoubtedly for this course of procedure to extend. This is largely due to the increased demand for wools on the part of the United States, France, Germany, and Japan. Wool bought for any of these countries is most reasonably shipped direct, although it is really most curious to note how London or even Liverpool

may be employed as the centre for distributing wool, in some cases the wool being actually sent to the place whence it originally came. A factor of importance in the development of the direct trade is that wool-growers realise more quickly on their product, although as against this it has been urged that the grower will realise better by waiting for the London sales. This has undoubtedly been true many times of late, but it is questionable whether the better price realised has been accidental or is a stable possibility.

The regular selling season extends over six months of the year—that is, from October to March; and the tendency at present seems to be to lengthen this. Of the Australian clip, 70 per cent. is sold in Australia, and of the New Zealand clip about 40 per cent. is sold in New Zealand. Selling is very largely in the hands of brokers (as, for example, Dalgety and Co., Goldsbrough, Mort and Co., The Australian Land and Finance Co., etc.), who regularly advance money to growers on the security of the clip. The following are the chief selling centres in Australasia:—

Sydney	Brisbane	Christchurch
Melbourne	Wellington	Timaru
Geelong	Napier	Invercargill
Adelaide		

Irrespective of charges of interest when the clip, as is very often the case, is mortgaged to a broker, the selling brokers receive ½ per cent. commission.

From wool stations in reasonable proximity to railways transport by train is universal, while from inland stations horse, bullock, and camel teams convey the wool to the nearest railway connection. Under these latter conditions wool is often weeks on the road, and is consequently relatively dearer. In some few instances

steamboats are available. In all cases, however, the destination is, naturally, the selling centre near the port from which shipment to the manufacturing centre takes place. At this selling centre the wool is warehoused and there may be inspected by the selling brokers and buyers.

Shipment—by sailing-boat or steamship—to the manufacturing centre is under the owner's or purchaser's direction. Sailer freightage charges vary from $\frac{1}{16}$d. to $\frac{1}{8}$d. per lb., this being less than the steamboat charges, no doubt to compensate for the longer time required for delivery. The extent to which sailer freight is employed thus naturally depends upon the state of the market, and also on the rates ruling for steamboat. Steamboat charges are about $\frac{1}{2}$d. per lb. for greasy, and $\frac{5}{8}$d. per lb. for scoured wool, but these again vary according to demand. Insurance is effected on what are termed "lots," the rate being $\frac{3}{8}$ per cent. (7s. 6d. per £100) on declared value per broker's invoice, plus 10 per cent. for profit which it is assumed will be realised.

Prior to shipment wool is "dumped"—that is, the bales are compressed, as space on the boat is, of course, important. The removal of the wool for this purpose from the broker's warehouse is possible the day after payment is made.

Direct Trade with London.—Considerable quantities of wool (some of which may have been sold in Colonial centres) are sent to brokers in London to be brought under the hammer at the Coleman Street Sale Room, E.C. Six series of wool sales are held every year, of which the following are the approximate dates :—

January 19th	May 4th	September 21st
March 9th	July 6th	November 23rd

As the Antwerp wool sales are held a fortnight prior to those of London, buyers from the Continent, America, and from all other centres of the textile industry are to be found in attendance. The wool to be sold is open to inspection at the wharf warehouses the morning of the sale, when the buyers have every opportunity of estimating the quality, sinkage, tear, etc. Selling commences each day in the sale room at Coleman Street at 3 p.m., ordinary bulk lots being sold first and "star" lots—that is, three bales and under—later. At these sales pandemonium reigns supreme, many buyers making the same offer without any individual expressing willingness to advance the necessary halfpenny, which is the only advance accepted on wools over 8d. per lb. The auctioneer's task is proportionately great in distributing lots amongst the aggressive bidders, as he naturally wishes to give satisfaction by an equitable distribution. Bids are only accepted from those buyers who have seats allotted to them, such allotment being for a period of years. Seeing that the lots offered total up to very large weights, small dealers are practically debarred from buying save through buying brokers, to whom a commission of about ½ per cent. is paid.

The terms on which purchases are accepted are net cash within fourteen days, an arrangement which necessitates an allowance for difference between trade terms being made by buyers on material as sold, say in Bradford, where terms are cash within fourteen days less discount at 5 per cent. for four and a half months, or 4½d. in the £. This is usually met by allowing ½d. for wools under 1s., 1d. for wools under 1s. 6d., and 1½d. for wools costing up to 2s., and so forth.

Carriage from London to Consuming Centres.—Wool may be distributed from London to Bradford or

other manufacturing centres either by rail or steamboat. The Bradford rates are :—By rail, 30s. per ton ; by steamboat (Hull and Goole), 22s. 6d. per ton. Railroad transport gives advantage in speed—usually one day or night as against four days. Thus, wool bought, say, on a Wednesday and invoiced by the broker next day, may be collected by the railway company's carriers on the Thursday evening, railed to Bradford by Friday morning, and delivered to the comber by noon of that day, thus allowing in special cases a sample ball of the top to be exhibited on the market by the following Monday.

C. **Cape Wools.**—A fair proportion of Cape wool is usually sold in London. As would be expected, however, local storekeepers in South Africa purchase wool from growers and sell it at Port Elizabeth and other distributing centres to European representatives of manufacturing firms, who ship it direct.

D. **Foreign Wools—South American.**—South American wools are sold in Monte Video (fine wools), Buenos Ayres (cross-bred wools), and Bahia Blanca (cross-bred wools). In Buenos Ayres, for example, wool is exhibited in the Market Hall and purchased in the rough, as it were, and sometimes forwarded to European centres for sorting, even though it may be returned later to the United States. Upon the whole, however, buying is much on the same lines as already described, but the unit weight is 10 kilogrammes and payment is in paper dollars. A good deal of South American wool is sold at the Antwerp sales, of which six are held annually, just a fortnight prior to the London sales. So-called River Plate and Punta wools are sold in London, while some proportion of South

American wool is also sold at Liverpool, of which sales the following are the approximate dates *:—

January 26th	May 25th	September 28th
March 23rd	July 27th	November 30th

Some European buyers buy direct from the growers, so that the South American wool trade is somewhat complex in its working. Transport is naturally by steamboat. If Bradford or the Continental centre is the port of destiny the charge is 7s. to 9s. per 40 cubic feet, this being the size of an average "B.A." bale (450 kilogrammes). Insurance is effected at the same rate as for Colonial wool.

Trade Routes.—Though not of prime importance to all interested in the raw material of the woollen and worsted trade, the question of the time taken during shipment, the charges made, and so forth, are of such general interest as to merit attention to the trade routes followed during the transport of textile products from the producing to the consuming centres. As an aid in this connection the map of the world facing page 10 should be referred to, in which the trade routes may be readily traced.

Condition or State in which Wool is Shipped.—Probably three-fourths of the Colonial and foreign clips is shipped "in the grease"; a very small and declining proportion is "fleece washed," and the remainder is "scoured." The fleece washing referred to is effected by either washing the wool on the sheep's back or washing the wool in fleece form after shearing from the sheep, the fleeces being run over rollers and subjected to a warm water spray. The question of shipping in the grease or in the washed or scoured state was very

* It is thus evident that the original idea was for Antwerp, London and Liverpool to follow one another in sequential order.

hotly debated some years ago. The points "for" and "against" in each case are set out below.

When shipped in greasy state:—

Advantages

Suint or yolk (grease) present, which preserves the nature, colour and form of the fleece. The colour is thus better, and sorting, if necessary, can be more conveniently and cheaply carried out.

When scouring is performed by the comber the wool may be treated just according to requirements.

Grease, as in wool, is useful; it aids the scouring of less greasy types often used in blends, thus saving cost in soap. It also yields potash salt (obtainable from the liquors—which are valuable scouring agents), and fat.

Disadvantages

Increased cost of carriage and freightage.

In the case of some wools that contain much sand and earth, discoloration of the wool results through contact in packing. Again, the longer impurity of this character remains in the wool the greater the risk there is of harshness and brittleness.

Difficulty in estimating the "yield." This difficulty increases with the amount of impurity.

Wool to scour. This means additional cost of, say, ½d. to ¾d. per lb.

When shipped in a fleece-washed state:—

Advantages

Some saving in carriage or freightage, varying according to amount of impurity removed.

Form of fleece preserved.

Sufficient grease present to keep the fibre staples soft and elastic.

Easy to estimate for "yield."

Disadvantages

Cost of fleece-washing operation—not very expensive.

Wool to scour—cost, say, ⅛d. per lb.

Not sufficient impurity removed by this operation in many cases to bring wool within a reduced freightage rate, nor so as to bring relatively higher price when marketed which compensates for loss in payment on reduced bulk.

When shipped in scoured state :—

Advantages	Disadvantages
Maximum saving in carriage and freightage charges.	No preserving grease in fibres.
Easy to estimate for "yield."	Often badly scoured, and consequently discoloured, harsh and matted. Agents may have been used which interfere with subsequent processes of scouring and dyeing.
Minimum scouring cost.	Some little dirt is gathered in handling and transit which makes a short scouring operation necessary. Cost, say, ⅛d. per lb.
	Fleece and staple formation interfered with ; bad to sort ; slightly more wasty in combing.
	No greasy residue (from impurity) of value.

From the foregoing it will be very evident that much depends on the position of the station where the wool is grown, upon the condition of the wool—that is, whether very greasy or fairly clean—and upon the charges ruling for transport. So far as the manufacturing centres are concerned, wool is preferred in the grease, no doubt largely on account of scoured wool so frequently being discoloured and felted. In the future it is probable that a desirable increase in fleece-washing will come about, for this system is economical so far as transport is concerned, and at the same time sufficient grease is left in the fibre to preserve its nature.

Cape wool, however dirty, should always be shipped in the grease, owing to the fact that the fibre is so fine, soft, and curly that after press-packing in the

scoured state it cannot be opened and re-washed without considerable injury. Thus efficient scouring would not mitigate this difficulty.

With reference to South American wools much improvement may be effected in the scoured wools shipped. These are often very dirty, the fleeces appearing to have been left unopened and simply to have been dragged through crude wash-bowls and very much matted together.

HAIRS: BUYING AND SHIPMENT

Turkey Mohair. — Turkey mohair is collected from the small farmers and afterwards sold at such distributing centres as Constantinople. It is usually packed in small bags; but, upon the whole, the method of preparation and packing is somewhat primitive. Bradford houses are represented by buyers in Turkey who buy direct from the growers.

Cape Mohair.—The representatives of Bradford firms buy up the clip privately, or it is collected in shipments by storekeepers and consigned for sale in London by brokers.

American Mohair.—As this, comparatively speaking, is a new industry, it is not quite stable as yet, but the tendency is for the mohair manufacturing concerns of the States to purchase direct all they can lay hands on of a good quality.

Alpaca.—Alpaca is shipped from Peru and Chili (Arequipa), and, along with camel's-hair, cashmere, goat's-hair, and Chinese, Russian, Egyptian, Persian, and other low sorts of wool, is sold at the Liverpool wool sales.

Commerce in Skin Wools.—The skin wool trade has markedly developed of late. Skin wool sales are held in the Colonies, South America, and in London, at which sales buyers representing fellmongering firms attend. Brokers collect the skins from the mutton-freezing centres and classify them. These are then pulled (*see* Chapter III., p. 71) at Colonial, Continental, and Home pulling centres. Home skins are often treated locally, many being bought directly from the butchers by the puller.

The pulled wool is offered at London and the Colonial centres. Mazamet, in France, perhaps the greatest wool-pulling centre, samples its wools through agents to all parts of the world, who offer to prospective buyers "if unsold." If the bargain is struck the passing of a sample bale—say, fourteen days later—decides the transaction. Large quantities of skin wool are used in Bradford as blending material, exceptionally good yield and tear resulting with the tops made.

WOOL AND HAIR WASHING

British Wools.—With British wools, wool-washing on the sheep's back is usually a distinct advantage; thus in Bradford, while it is stated that Merino wools can be better judged in the grease, it is also admitted that lustre wools can be better judged in the washed state. By washing, the wool is made more attractive, and owing to the long, smooth, and non-felting characteristics, little or no injury is done during the process, or subsequently. About 72 per cent. of British wools are washed, but in some few cases the climate, character of water, and condition of wool do not lend themselves to this

operation. Upon the whole, wool-washing pays. In an investigation carried out by Mr. Bernard M. Wale, B.Sc., of the South-Eastern Agricultural College, Wye, it was found that for a wide range of fleeces sold over a period of many years the washed types averaged 4.17d. per fleece more than unwashed. Unfortunately, the tendency is for washing to decrease, owing to cost, injury to sheep (particularly if weak), and the danger of transmitting scab.

Washing most largely obtains in the Midlands and northern portion of England, with the exception of Northumberland.

A fair proportion of English "Down" wools are washed.

Very little Devon, Cornwall, and Surrey wool is washed.

Scotland washes comparatively little, and Ireland washes a great deal of the wool produced.

Description of Washing.—In this country washing is effected as follows. A suitable stream is dammed up, and fencing is then so arranged as to drive the sheep up to the water, or to a walled yard close to the water, with an opening into the dam (or equipped with a circular trough). The sheep are dropped into the stream, immersed once or twice by the washer standing in mid-stream, or by men standing on the banks with crooks, and are afterwards driven into a clear grass field, where they may dry without any fear of contamination with straw or other unsatisfactory vegetable matter. By this means much dung and dirt which would cause expense and inconvenience in the subsequent processes is removed. The cost may reach ½d. per head. It is not advisable in this process to employ anything other than cold water.

Dipping.—Two or three times during the growth

of the fleece (twelve to fourteen months) dipping is almost of necessity employed to overcome the harmful influence of ticks, lice, etc., which would tend to produce scab. A good dip may be useful as regards the wool. It may lubricate the fibre, giving softness and elasticity, and may even improve the colour by slightly bleaching it. Dipping with unsatisfactory agents, however, is most harmful. The wool is made weak and brittle, its growth is stunted, its colour will probably be unsatisfactory, and in the processes through which it must subsequently pass it is most difficult and costly to manipulate. The harmful dips are generally supposed to be :—

Lime and sulphur combinations,
Tobacco compositions,
Pitch oil preparations.

Among the satisfactory dips are :—

Arsenical dips (like Quibell's),
Carbolic acid and oil (MacDougal's).

It is but fair to add, however, that claims are made on fairly satisfactory grounds that lime and sulphur do not seriously affect the wool. Again, farmers frequently employ special dips to "get-up" wool on the sheep's back for show purposes. The point at issue is as to whether the harmful dips have a lasting influence upon the wool, or whether the wool, as it were, in the few months' subsequent growth throws them off and attains to its natural condition. Upon the whole, there is here ample room for further experiment.

Branding.—After shearing, branding is necessary in order that the sheep on a special farm or station may be recognisable. Marking of the ear and hoof obtain,

but these marks are not sufficiently distinctive for general and easy recognition; some larger mark on the wool is necessary. Tar was formerly employed, but has been found very injurious to the work, and consequently wasteful; wool thus treated must be separated and used for low-class goods on account of discoloration. Branding agents are now available, composed of vegetable oils and non-injurious colouring matters. These will withstand the influence of the growth of the staple, rain, and light, and will wash out fairly well in an alkaline bath. In all cases brands should be applied by means of a proper stencil.

SHEARING

British Methods.—Very crude systems of shearing wool still prevail in this country. Hand-shears are frequently employed, producing much "fribby"—that is, double-cut—wool, and often leaving the staple shorter than it need be. On the other hand, if automatic shears are employed, it usually means one man turning a handle while the other man shears, so that the shearer must shear at least double the number of sheep to compete with hand-shearing. Deficiencies of this kind must be attributed to the comparatively small number of sheep to be dealt with per farm.

No system of trimming or classing the fleeces obtains. They are simply wound inside out, bound with a tassel made from the shoulder, and packed by the buyer just as taken from the sheep's back. If intended for the export trade, "casing"—that is, classing according to quality—is carried out by the stapler. At no stage is press-packing employed, but the fleeces are packed in large sheets, very different in form from the Colonial rectangular bale.

Colonial Methods.—In the Colonies, as a rule, most up-to-date arrangements prevail. The operation of shearing a large flock of sheep is effected as follows. In the separating yards of the sheep station "hog" sheep are separated from "wethers," and a rough classification thus effected prior to shearing. Each class is now directed to some special part of the shearing shed, thus expediting both the handling and classing of the wool. The sheep pens from which the shearer draws his sheep are convenient of access from the shearer's board, while equally conveniently placed are the pens for the shorn sheep. Machine shearing is almost universally in vogue, it being more thorough, cheaper, easier for the shearer, and less painful for the sheep.

The mechanical shearer consists of working combs with inner faces sharpened, centred so as to work as ordinary scissors. They are driven mechanically from the main shaft of the room through many-jointed or flexible shafting.

The shearer begins at the neck of the animal, works down the front, and then round to the back, allowing the fleece to fall back as a shroud until severing is completely effected at the haunches, where the leg portion of the wool is pulled off and the fleece left for removal by the "rouse-about" (a shed hand). The sheep is now turned into the shorn sheep pen, while the fleece goes to the skirting table, where the dirty and lower portions are removed and it is then rolled inside out, with the sides wrapped over and rolled from the tail. It is finally "classed"—that is, put in a quality agreeing with the bulk sort—and "stacked" until packing. A special section of the shed is reserved for the skirting, classing, and packing of the fleece.

Baling is the packing of the wool in hemp packing, giving, say, a 3 ft. 6 in. by 2 ft. by 6 in. bale, weigh-

ing about 2½ cwt., for Botany wool, and a 4 ft. by 2 ft. 6 in. bale, weighing 3½ cwt., for cross-breds. The hemp packing must necessarily be made from good hemp spun into threads of a closely-twisted character, which in turn must be woven into a smooth face, tight cloth, inside which corrugated paper lining is advisably placed, this, so far as may be, excluding contamination with vegetable fibre. It is interesting to note that the most important firms of wool users are willing specially to consider wools forwarded in packing of the above-defined type.

Actually to make the bale, fleeces are piled in orderly fashion in a strong wooden, bottomless box, inside which the bagging is placed as a lining. The sides of this box are hinged to admit of the finally completed bale being removed. Over this box another similar box is brought and wool is filled into both boxes from bottom to top. A ram, underneath the plate of which the top flap of the pack is fixed, is now lowered into the boxes and the whole bulk by this means compressed into one box and finally sewn up into one bag or pack. The top box being removed, the sewing of the top cover is effected, and afterwards the bottom box is removed, leaving the bale ready for the next process.*

Branding of bales.—In this process the particulars descriptive of the wool baled are stencilled on the bale cover. These are generally the district where the wool is grown, the name or mark of station where grown, the sort or type of wool—that is, whether fleece or pieces, hogs or wethers, first combing or second combing, etc.—and number and weight of bale.

* Owing to Australian wools being shipped by weight and South American wools by bulk, the latter are compressed into solid looking bales, which are necessarily bound by iron hoops. Punta wools are sometimes simply bound by wire bands. It is further interesting to note that South American fleeces are usually tied up with string instead of with the wool itself, a very harmful procedure.

Cape and South American Methods.—Considerable improvement is possible in regard to both shearing, classing, and the packing of these wools. In the case of the Cape, negligence and ignorance may be urged; in the case of South America, the cost of labour is a difficulty. The sprinkling in of sand and the introduction of rags, etc., are naturally to be deprecated. These practices, however, must be considered the exception.

TRADE TERMS APPLIED TO SHEEP AND WOOL

As some confusion exists with regard to these, an attempt at classification may be here attempted. Without undue egotism we would here urge that the following terms should, if possible, be adhered to:—

Teg.—Given mostly to male sheep of Down type from time of weaning to shearing.

Ewe-teg.—Applied to female sheep of Down type from time of weaning to shearing.

Gimmer.—Scotch term applied to female sheep. Generally used also in Yorkshire.

Half-bred.—A cross from two pure breeds.

Three-quarter-bred.—A cross produced by a half-bred crossed again on to a breed already represented.

Come-back.—The result of continued crossing towards one of the breeds originally employed. Merino Come-back is most commonly produced on account of mutton requirements, and also to gain fineness and softness in wool grown.

Cross-bred.—The progeny of two breeds not necessarily pure. A term largely applied to all cross-breds in the Colonies. Equivalent in Britain to the term "half-bred."

Mixed Breed.—The product of many crosses of varied types. Wool in which well-known characteristics are indistinct.

WOOL CLASSERS' TERMS

Matching.—Applied to various sorts of qualities as made from fleeces.

Combing Wool.—Of a length sufficiently long for combing purposes, say two inches and over.

Clothing Wool.—Wool too short for combing—that is, two inches and under—and most suitable for use in the woollen trade.

Super Combing.—The finest quality wool of the clip.

First Combing.—The bulk sort of the clip.

Second Combing.—Longer and coarser wool—a quality lower than the first combing.

Broken Fleece.—Sorts made from skirtings of fleeces and from low and dirty pieces.

First Pieces.—The bigger pieces of the dirty skirtings left after sorting broken pieces.

Second Pieces.—The smallest, dirtiest, and lowest portions from the skirting.

Locks.—Odd staples from skirtings, usually swept from under the screen of the picking table; very dirty and of varying quality.

CHAPTER V

WOOL CLASSING AND SORTING

The Classing of English Wools.—In the case of English wools there is no attempt prior to shearing to classify the sheep, and little is done in the way of classifying the fleeces after shearing until the wool stapler comes on the scene. Thus the wool stapler generally buys the whole clip—usually a comparatively small one—and receives it exactly as taken from the sheep's back. During the process of classing, the fleeces are examined in a good light and separated in the first place into "hogs" and "wethers"; this classification is dependent upon the appearance of the wool staples, the hogs being pointed at the tips, while wethers are more or less square, showing the cut of the previous year. The hogs, as a rule, are also finer and longer in staple than the wethers, often representing fourteen months' growth. After this classification the quality of each fleece is determined, each being classed as "super," "selected" or "picked," "ordinary" or "cast," and placed in its distinctive bin. Kempy and damaged fleeces are placed on one side and made into special lots.

The Classing of Colonial Wools.—This is carried out in the Colonies, and, so far as Australasia is concerned, is exceedingly well done, largely owing to

the fact that classing pays the grower, the buyer being ready to pay a better price for bulk lots of which he is certain of the quality, and in connection with which he knows that little additional labour will be necessary to prepare for the manufacturer. After "skirting," the fleeces are classed as "first," "second" or "third combing" or "clothing," according to length, fineness, soundness, colour and condition, etc.

Merino wools come from the highest class flocks and are very uniform in quality, and consequently, are chiefly classed from the point of view of condition, two or three grades being made. Other Merinoes are classed into "super-combing" (the very best of the clip, and consequently a small lot), "first combing" (the bulk type), "second combing," and "clothing" (this being produced from short fleeces).

Cross-bred wools are not usually very thoroughly skirted, and are classed as "super-cross-breds" (which are derived from fine cross-breds and Merino "come-back" sheep, ranging from 56's to 58's qualities), "first cross-bred combings" (46's to 50's qualities), "second cross-bred combings" (40's to 44's qualities), and "third cross-bred combings" (32's to 40's qualities).

In pure-bred Colonial sheep the long wools are classed as "hogs" and "wethers," the best hogs being branded as "extra lustre hogs" and the wethers as "lustre wethers." The better of the latter class are termed "fine lustre wethers." In the shorter types of wool, fleeces are classed as "tegs" (corresponding closely to "hogs"), if specially satisfactory, and the remainder are termed "wethers." Combing or clothing quality is not defined in this case.

In the case of lamb's-wool, fatty, stained and dirty portions of the fleece are removed, in the process of which the fleece is unavoidably disorganised, and

consequently, lamb's-wool comes to us packed as "firsts" or "seconds," according to the variation in length prevailing.

What are termed "pieces" come from the skirtings and edges, these being sorted into "broken fleece" (the largest proportion), "firsts" and "seconds" pieces and "locks," this being in the case of Merinoes. Cross-bred pieces are made into "pieces," "locks" and "discoloured"; a "bellies' sort" is also made.

In the case of Cape fleeces, there is much room for improvement of the classing, which now is happily claiming more attention. Fortunately most Cape wools are fine throughout the fleece; thus the neglect of this operation has not been so seriously felt as might have been the case had the fleeces been less uniform. Australian methods, by which uniform lots of "combings" and "clothing," and "first greasy" and "second greasy" are made, are now being adopted at the Cape.

South American wool classing has also been somewhat neglected, it only being attempted on the biggest stations. Even on these skirting and trimming have been imperfectly carried out, and the method of classing has not been all that could be desired. For example, in a B.A. bale, stated as 40's, cross-bred qualities varying from 32's to 46's, long and short, clear and burry, kempy and discoloured, will often be found in by no means small quantities. Low lots are occasionally found secreted in the middle of the fleeces.

WOOL-SORTING

A definition of wool-sorting would be "the dividing up of the fleece into the various qualities representing the variation in length, fineness, sound-

ness, and colour of the staples." This variation of staple is due to certain portions of the sheep being better nourished than others—for example, the shoulders, as compared with the haunches. It is also the result of certain portions being subjected to harsher treatment during growth, due to the natural habits of the animal. The lists given on p. 117 and the accompanying illustrations show the positions where the various qualities are to be found on representative fleeces, and may be used as a means of comparison.

The ideal condition from a wool user's point of view would be to breed a sheep which yielded an absolutely uniform staple throughout. As this is impossible, wool-sorting is a necessary operation. It may also be premised that without it fine yarn spinning would be impossible, as only the very finest wool of the fine fleeces can be used for this purpose. In practice, to sort wool is usually economical, because if a lower quality is worked along with a better quality, the former injures the latter to a greater degree than the low quality is improved through the influence of the better quality. By sorting, therefore, the best result is obtained from each fleece, as each variety of staple may be placed in its lot, which lot will subsequently receive the treatment best suited to develop its most favourable characteristics.

The extent to which sorting is carried on varies in part according to the trade centre, but more particularly according to the classes of wool dealt with. Thus America probably classes, rather than sorts, being mostly concerned with bulk lots, while Merino wools, as a rule, require less sorting than the low quality wools, being more uniform. As an example of this, English Lincolns, or more especially black-faced sheep, producing wool under severe climatic and difficult conditions,

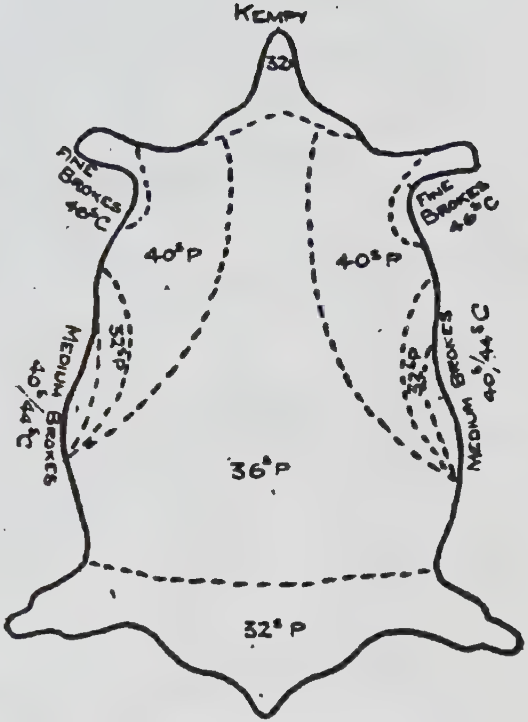


Fig. 34.—Lincoln Hog

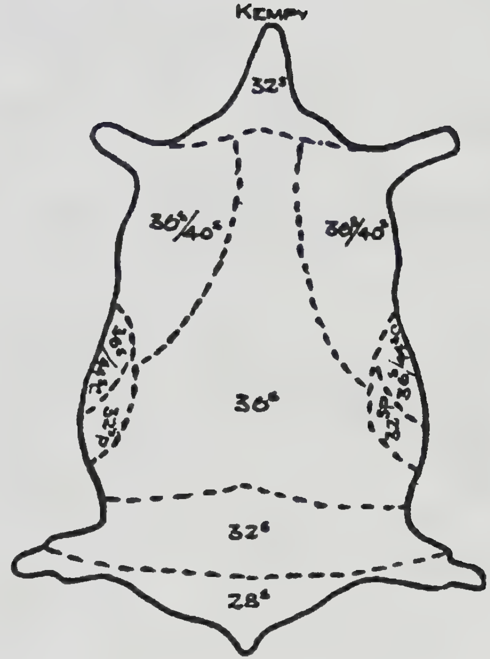


Fig. 35.—Lincoln Wether

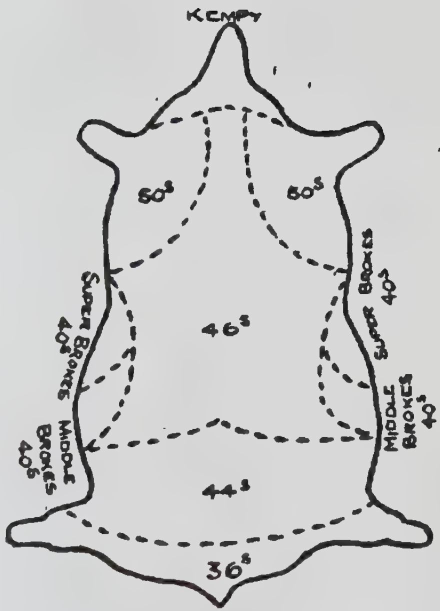


Fig. 36.—Cheviot

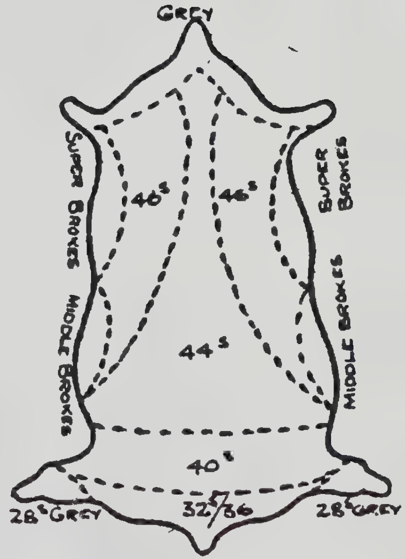


Fig. 37.—Kent

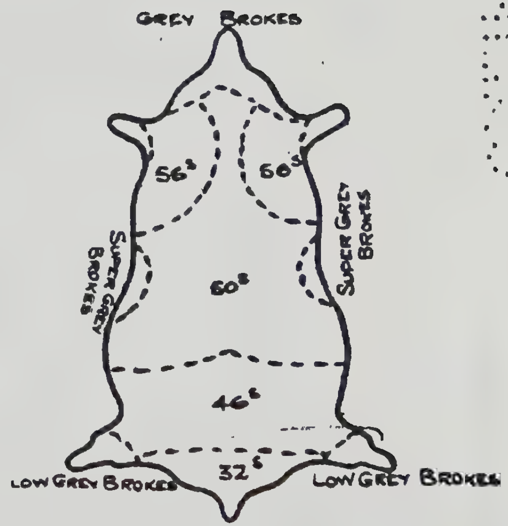


Fig. 38.—Southdown

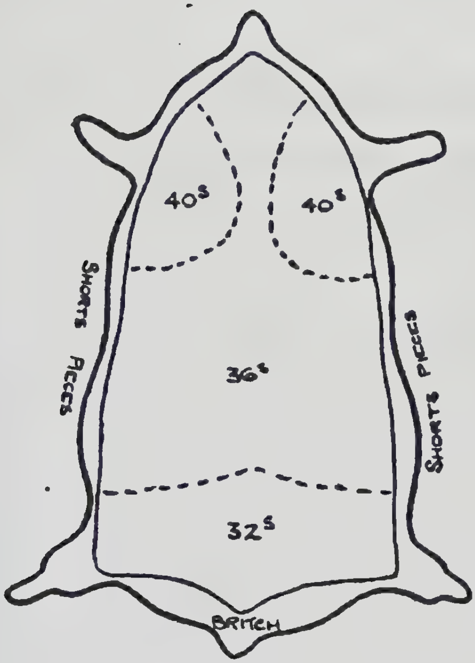


Fig. 39.—Low Cross-bred

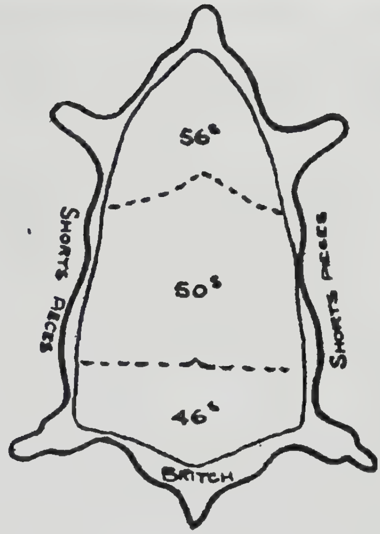


Fig. 40.—Fine Cross-bred

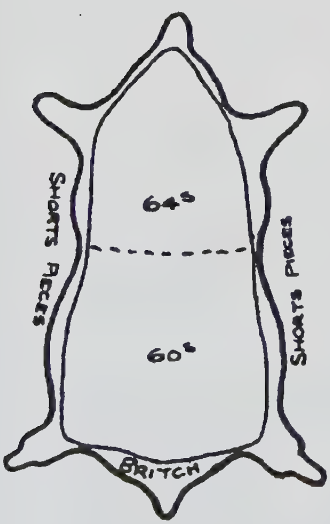


Fig. 41.—Merino

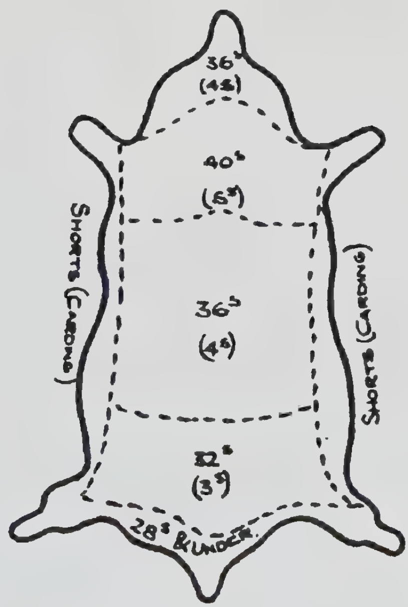


Fig. 42.—Medium Mohair

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are liable to yield variations in fleece along with such characteristics as kemps, grey wool, hairy and lustreless fibres, which the most careful breeding will not entirely eliminate.

Again, fleeces vary in the conditions in which they are received by the users. Colonial fleeces, for instance, are usually skirted and britched, while English are received just as they have been shorn. Naturally, more sorting is necessary with the latter types.

Although sorting is, as a rule, an advantage, it is not always carried out to the extent that the fleece naturally admits of. With Lincoln fleeces, for example, ten or twelve sorts could be obtained, but the little variations in the resultant yarns or cloths from these, and the expense incurred in treating such lots separately, would not justify the great cost of such careful sorting. Truly distinctive qualities only are therefore made, and in the case of firms whose tops are not so much super-excellent, as cheap and useful for general purposes, the minimum number of qualities are made.

The Wool-sorters' Equipment.—A usefully varied experience is the first essential in wool-sorting. By this means a sorter develops a keenness of perception and a fine sense of touch—factors which are of most importance in this trade. Again, quickness of decision is required, and also the facility of handling fleeces smartly. Having obtained a good general experience, it seems, then, as though it were better for sorters to confine their attention to one particular type of wool. In fact, it is possible to confuse classes and to alter the quality standards by changing sorters.

In dealing with Colonial fleeces, wood tabling is arranged about eight feet per man and sufficiently deep for the fleece to be fully exposed. For handling

English wool, screens or hurdles (wood frames with wire meshes) take the place of the table, and through these the dust, dirt, etc., fall. The sorting-room should be so arranged that a good north light is available. Thus, as a rule, the operation is carried out either in a shed or in a room at the top of a building. The latter is preferable, as in this, by "trapping," much labour in the conveyance of material is avoided. Skeps are given to each sorter for his regular "sorts," while under his table and in the window bottoms are thrown the tar bits and stained pieces, etc., which slowly accumulate. Shears are also supplied for cutting dung bits away. As some fleeces from the Colonies are very heavy in the grease, they become consolidated by the press packing, and heat is required to open them out. Ovens are therefore provided; these are about 9 feet long, 3 feet broad, and 2 feet deep; cheap coal is employed to heat them.

The actual operation of sorting is conducted as follows:—

Fleeces are weighed off to the sorter by the pack of 240 lb.

English fleeces are unwound and opened by loosening the tassel made from the shoulder. They are laid on the screen flesh side downwards, thus showing up clearly the whole exterior of the fleece, which so far has been wound up in such a way that all the low portions are inside, while the best wool is on the outside. They are now "rigged," that is, divided by way of the natural division from the top of the sheep's back, up the centre of the fleece, so that the fleece is of a size to be handled conveniently. Each half-fleece is then vigorously shaken to remove dirt and vegetable impurity, and placed in pile form until the whole pack has been dealt with. True sorting then begins, first

at the britch end, then up towards the neck, until the shoulder portions, usually the best in quality, are removed.

Cross-bred and Merino fleeces are much more quickly dealt with. They are not so large, so dirty, nor so varied in the qualities of wool they yield. Indeed, some of these are hardly sorted at all. The process is rather one of looking over, in which dirty and extra coarse locks and vegetable impurities are removed. No rigging of the fleece is carried out, and comparatively few qualities are made.

Hairs are extremely difficult and tedious to sort, on account of the smoothness and slipperiness of the staples, which causes disorganisation of the fleece as soon as it is shorn. Practically, individual staples must be dealt with; sorting by position is almost impossible.

Wool-sorters' Terms Applied to Qualities.—Considerable variation is to be noted in the use of sorting terms. Thus terms in the woollen trade differ from those in general use in the worsted trade. Again, numbers and letters are frequently employed to maintain secrecy with regard to the composition of blends into which such qualities ultimately go. The terms and quality numbers tabulated on p. 117 represent the various methods employed, and in Fig. 43 actual photographs of typical staples as taken from a range of qualities found in a lustre fleece are illustrated, from which an idea of the variations obtaining in practice may be gained.

In longer qualities "prepared" and carded" sorts are usually made, and in finer qualities "super," "warp" and "weft" qualities are frequently to be met with.

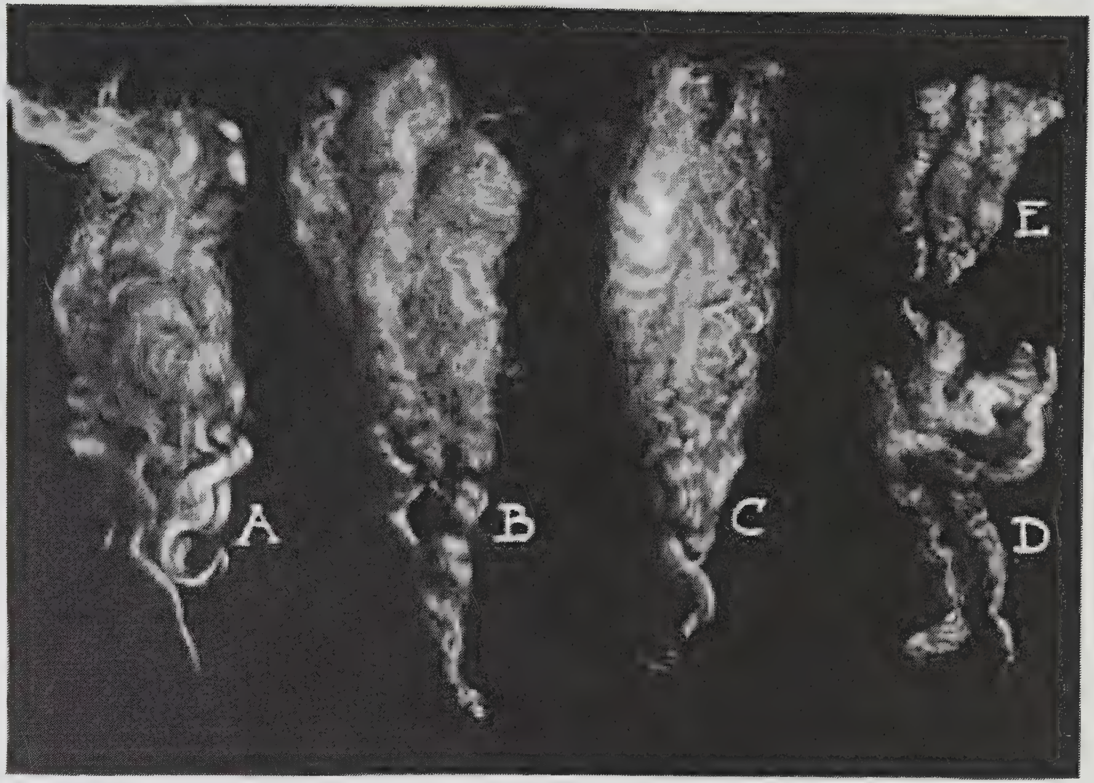


Fig. 43.—Wool-Sorter's Qualities

A, From Haunches B, From Middle of Side C, Shoulders D, Discoloured E, Shorts

English Worsted		Colonial Worsted	
Term	*Quality Represented*	*Term*	*Quality Represented*
"Fine" . .	44's	11's	60's
"Blue" . .	40's	10's	56's
"Neat" . .	36's	9's	50's
"Brown" . .	32's	8's	46's
"Britch" . .	24's	7's C.	40's & 44's
"Cowtail" .	18's	7's P.	40's
"Downrights"	40's short	6's	36's
"Seconds" .	32's short	5's	32's
"Abb" . .	24's short	4's	28's

Mohair		Woollen Terms
Term	*Quality Represented*	
9's	Super	"Picklock"
8's	60's	"Prime"
7's	56's	"Choice"
6's	50's	"Super"
5's	46's	"Seconds"
4's	40's	"Downrights"
3's	36's	"Abb"
2's	32's	"Britch"
1's	28's	

* Quality numbers are not usually attached to sorts in the woollen trade. The terms given above signify a variation in spinning capacity somewhat similar to that given in respect of the Colonial worsted list.

ANTHRAX AND ANTHRAX REGULATIONS

The following description of anthrax, taken from Government publications, is possibly the best statement that can be made on the matter.

"Anthrax is a fatal disease affecting certain animals, which may be conveyed from them to man by the

handling of wools or hairs from animals which have died of the disease. The germs of the disease (Anthrax spores) are found in the dust attaching to the wool, or in the excrement, and in the substance of the pieces of skin, and may remain active for years. In Great Britain and Australia anthrax is rare, consequently there is little danger in handling wools from the sheep of these two countries; but in China, Persia, Turkey, Russia, the East Indies, and in many other parts of the world, the disease is common, and infected fleeces or locks (which may not differ from others in appearance) are often shipped to Great Britain. Hence, in handling foreign dry wools and hair, the Regulations should be carefully observed. Greasy wools are comparatively free from dust, and therefore little risk is incurred in handling them.

"The disease is communicated to man sometimes by breathing or swallowing the dust from these wools or hair, and sometimes by the poison lodging in some point where the skin is broken, such as a fresh scratch or cut, or a scratched pimple, or even chapped hands. This happens more readily on the uncovered parts of the body, the hand, arm, face and, most frequently of all, on the neck, owing either to infected wool rubbing against the bare skin, or to dust from such wool alighting on the raw surface. But a raw surface covered by clothing is not free from risk, for dust lodging upon the clothes may sooner or later work its way to the skin beneath. Infection may also be brought about by rubbing or scratching a pimple with hand or nail carrying the anthrax poison. Use of the nail brush, and frequent washing and bathing of the whole body, especially of the arms, neck and head, will lessen the chance of contracting anthrax.

"The first symptom of anthrax is usually a small,

inflamed swelling like a pimple or boil—often quite painless—which extends, and in a few days becomes black at the centre, and surrounded by other 'pimples.' The poison is now liable to be absorbed into the system, and will cause risk of life, which can be avoided only by prompt and effective medical treatment in the early stage, while the poison is still confined to the pimple. Hence, it is of the utmost importance that a doctor should be *at once* consulted if there is any suspicion of infection."

The Factory Act of 1901 enforces certain regulations regarding the treatment of these dangerous wools. Van mohair and Persian wool, prior to being willowed and sorted, must be thoroughly steeped before the bale is opened. Alpaca, Peliton, East Indian, Cashmere, Russian camel's-hair, Persian, or so-called Persian, including Karadi and Bagdad, if it be willowed and sorted, must be steeped and opened over a regulation screen or board. All other than Van mohair, if to be sorted, must be dealt with on a special screen provided with downward draught. The most recent discovery with reference to wool-sorters' disease is that blood is the main carrier of the germs. Thus workpeople should be specially careful in dealing with blood bits, fallen bits, and skin bits, which should all be steamed.

The details of the open screens are as follows: These must be 12 ft. square and supplied with an exhaust draught working at a velocity of 150 feet per minute and measuring 18 inches from the centre of the screen.

The sorting boards are made as follows:—

The screen is of wire work, underneath which is a clear space of not less than 3 inches. Then comes the tin tray, leading down to the funnel of 10 inches or

more, which in turn leads to the extraction shaft. The air draught in this case should be 75 ft. per minute, measured 12 inches from centre. The dust must be discharged into a suitable receptacle and burnt. An air space of 1,000 cubic feet must be allowed for each operative.

CHAPTER VI

THE PHYSICAL AND CHEMICAL PROPERTIES OF WOOLS, HAIRS, ETC.

1. **Length and Diameter of Fibre.**—The most important characteristics of the wool fibre are its length and diameter. As will be gathered from the statements made in Chapter III., p. 52, and Chapter V., p. 114, length and fineness and a certain undefined relationship of the two decide what is spoken of in the wool trade as the "quality." There is, however, a more subtle definition of "quality," which would take into account all the physical characteristics and also the causes of such differences as result in Welsh wools, shrinking less on being washed, Shetland wools handling softer and so forth. The more practical definition, however, is the one which chiefly concerns us here.

As the length and diameter of fibre have been clearly indicated in Chapter III., pp. 52, 59 and 65, there is no need to deal further with the question at this point.

2. **The Cell and Scale Structure of Typical Wool Fibres.**—The structure of the wool fibre is peculiar and complex, being of a nature comparable with no other known fibre. Its peculiarities need to be thoroughly understood, otherwise the fibre will not be given that treatment which will render it best fitted for conversion into the most useful and best wearing fabrics.

If the natural wool grease present on and in the raw fibre be removed by boiling in a weak alkaline solution, the fibre, under the microscope, will then be found to be fairly cylindrical in shape and on the exterior to show certain peculiar surface markings formed by round, plate-like cells or scales which overlap each other and more or less stand off from the body of the fibre (Figs. 44, 45, 46, and 47). These exterior scales vary very considerably in shape in the different types of wools. Some appear to form rings round the fibre; others are cylindrical; and others almost pointed. In Merino wool fibres as many as 5,000 scales per inch are counted, taken in a straight line along the fibre. English Down wools give about 2,500, and English Lustre wools about 1,800. As will naturally be expected, the variation in surface structure, i.e. in scaliness, largely accounts for the lustrous or non-lustrous characteristics of the several wools, the presence or absence of this quality being due to the way in which the light is reflected from the surface of the fibre.

To investigate the internal structure of the wool fibre, transverse or cross sections must be cut, this being effected by embedding the fibres in wax or some other similar enveloping and controlling substance and then shaving off the sections by means of the microtone, or, in the absence of such an instrument, by a finely sharpened razor. Under the microscope such sections usually reveal the presence of three types of cells, viz. rounded or oval-shaped cells in the central or medullary portion of the fibre; more elongated or spindle-shaped cells in the middle or cuticle portion; and flattened cells or horny scales, these latter being sections of the exterior wool scales already referred to. The colouring matter of wools which are not white is found to reside in the

Fig. 44.—Fibre of Yorkshire Wool

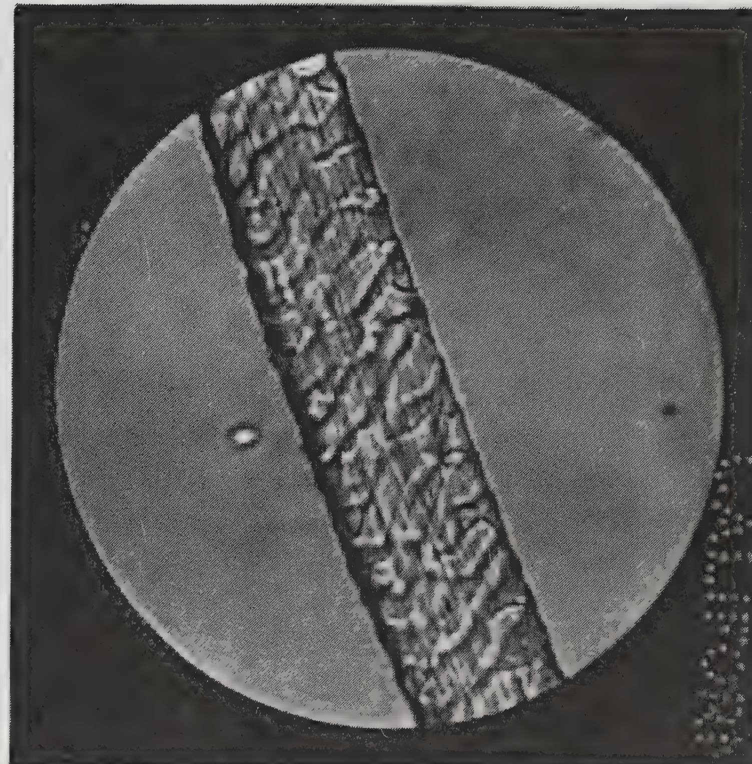


Fig. 45.—Fibre of Scotch Blackface Wool

(Magnified 330 times)

central or in the cuticle portion. Fat globules and air are also to be noted in the central portion, these no doubt playing some part in deciding the real nature of the fibre.

Ordinary and microscopical examinations reveal many valuable features respecting the fineness, length, colour, lustre and straightness of the various wool fibres. It may be argued that no result of practical value is possible when working with the microscope, owing to the limited field covered; but even in this case it is found possible to average up and often obtain results of a practical character. While working with the unaided faculties or with the microscope, extremes must obviously be avoided and deductions made from the bulk proportion.

The following list gives a good idea of the physical characteristics of typical wools:—

Type	*Scaliness*	*Length*	*Fineness*
	(Per lineal inch)		
English Lustre	1,800	10 in.–12 in.	1-600 in.
English Down	2,500	3 in.–4 in.	1-900 in.
Colonial Medium Cross-bred	3,000	5 in.–7 in.	1-750 in.
Colonial Merino . . .	5,000	2½ in.–3½ in.	1-1200 in.

Type	*Lustre*	*Colour*	*Softness*	*Straightness*
English Lustre .	Very lustrous	Yellowish	Fairly firm	Very straight
English Down .	Non-lustrous	White	Soft	Crimpy
Colonial Medium Cross-bred .	Fairly lustrous	Fairly white	Fairly soft	Fairly straight
Colonial Merino	Non-lustrous	Very white	Very soft	Very crimpy

Much of the value of wool as a textile fabric must be attributed to the previously-mentioned characteristics. Thus in the mixing which takes place in the various preliminary processes, fibres upon the average will be placed root to tip and tip to root, and it is conceivable that the scale structures will thus come into action, resulting in an interlocking of adjacent fibres. Again, on the principle that "in union is strength," the interlocking or felting of the wool explains, at least in part, the durability of the wool fabric. The tendency of the wool fibre always to revert to its original form may also be made use of, the extension of the fibre in the various spinning processes resulting in the final production of a fabric which has only to be subjected to the processes of "finishing" to contract and resolve itself into the typical woollen or worsted fabric. The softness and elasticity of wool, due to its nature and physical structure, may also be taken advantage of and made a special feature of the fabric into which the wool is finally woven.

It will further be gathered that usually the thickest, least scaly, and longest fibres are the most lustrous. On the other hand, fibres of the finer class are scaly, crimpy and usually relatively strong, spinning into strong and durable yarns, owing to their ability to resist "slip." For it should be noted that the strength of a thread depends upon two factors, viz. absolute strength of the fibres in the cross-section, and the "binding" effect of fibre on fibre.

The tendency to "felt" or "mill" which the different wool fibres possess in varying degree is one of the most valuable characteristics, and is found in no other fibre. This quality, however, must not be taken to reside entirely in the external scale structure. It seems to be partly dependent upon the actual shapes of the

scales and the refined nature of the fibre itself, as well as upon the crimpiness of the fibre. This probably explains why Cape wools, which in number of scales and crimpiness are equal to Australian wools, are less satisfactory felting wools. In the former case the crimp is less pronounced and the scales are not so clearly defined. The affinity of the wool fibre as regards moisture and the various dye-stuffs, and its action when treated with certain re-agents, are exceptional and must be attributed to its porosity as well as to its more refined nature.

The Growth of the Fibre.—The growth of the wool fibre may usefully be studied, as by this means its characteristic features may be the better accounted for and understood. The fibre is produced in what is known as the hair-follicle—a pear-shaped depression of the skin—and it has its origin in a group of cells (*see* Fig. 48). Examination of the skin itself, Fig. 49, reveals a complicated structure, which naturally favours both the origination and development of the fibre. The skin is mainly composed of two parts, the epidermis D and the dermis E, but each of these is found capable of further sub-division, as will be found on reference to Fig. 50. In the epidermis there is first to be noted the cuticle or scarf-skin, S S, which is composed of dead cells, flattened, dried, and horny; under this the *rete mucosum*, or true skin, S G, is found, which is formed of smaller flattened cells more densely organised. Both these layers are produced from the dermal layers beneath during the process of growth, and their more important function is to preserve and protect the more delicate texture which underlies them.

The dermis, or inner skin, is composed of two layers

(*see* Fig. 49 and portion marked D), the *papillary* or vascular, and the *corium* or deep-seated skin. The papillary P is in the upper position, and its surface is cone-like, consisting of a dense tissue of blood-vessels and nerves. In the corium C the bases of the hair sacs are formed, together with sweat glands, sebaceous or oil glands, clusters of fat globules, or adipose cells, and their various connecting ducts, and also blood-vessels and nerves. The sweat or sudoriferous glands, as they are termed, collect the grease and moisture from the adipose cells and discharge it through specially formed channels to the surface of the skin as "perspiration." Sebaceous glands fulfil a different purpose. They are of a distinctly different structure and arrangement, and produce an oily excretion which is conducted to the fibre follicle and acts as a lubricant, being useful in preventing irritation during growth, and of further value in giving to the fibre a high degree of softness and suppleness. The hair follicle is formed by an involution of the skin, and is the result of a process of cell division and re-division. Three stages may be noticed in Fig. 51, A, B, and C. During formation, a portion of the inner skin—the dermis—becomes enclosed and creates a papilla (*see* H P, Fig. 48), on which the fibre is subsequently built. This papilla contains the necessary tissues by which plastic lymph is supplied for the formation of cells and to assist in their re-division. As the cells round the papilla multiply, they are forced up the fibre follicle, ultimately forming the fibre shaft, as seen in Fig. 52. On reaching and forcing their way through the surface of the skin, at the point where the follicle is smallest, lateral pressure is applied to the fibre; thus the outer cells are forced into closer proximity and made to assume the flattened and scale-like form which

Fig. 48.—Hair Follicle

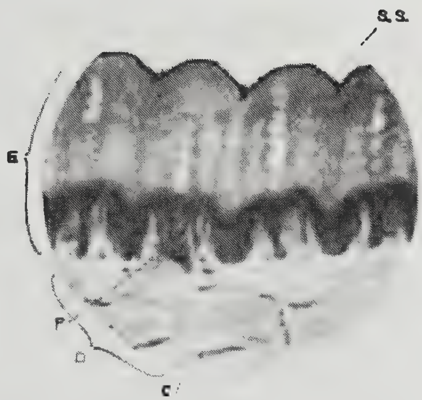


Fig. 49.—Section of Skin

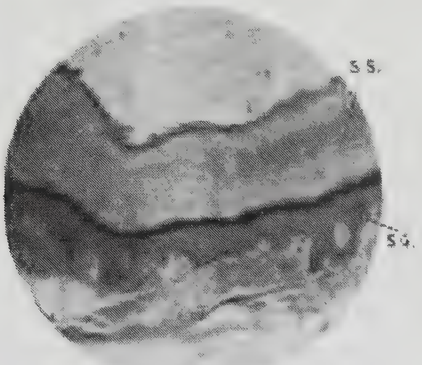


Fig. 50.—Section of Epidermis

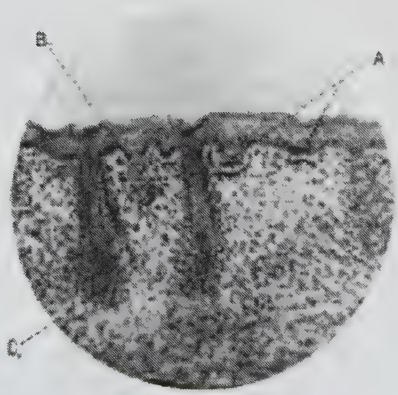


Fig. 51.—Three Stages of Formation of Hair Follicle

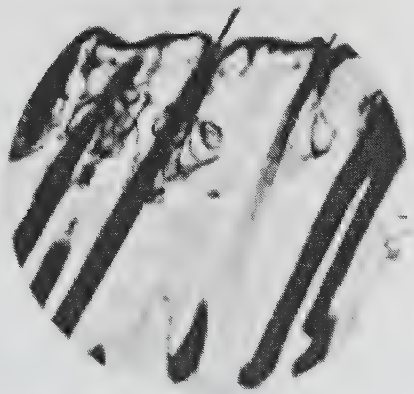


Fig. 52.—Showing Formation of the Fibre-shaft

For the micrographs here shown we are indebted to Dr. Woodhead of the Huddersfield Technical College

give the wool fibre its characteristic scale-like structure.*

Physical Characteristics of the Various Hairs Compared with Wool.—The differences between wool and hair are somewhat difficult to define. In chemical composition they are alike, and the difference in their physical structure is not readily noticed save in the most extreme types. This difference, however, is noticeable in Figs. 53 and 54, which illustrate typical mohair and wool (Merino). Lustre wool (closely related to hair) is shown in Fig. 55. Curiously enough, although what may be termed chemical and physical methods fail in determining the difference, still in actual practice in handling the respective materials little difficulty is experienced in discriminating between them. The following comments respecting differences between particular hairs and wools may prove useful.

(*a*) **Mohair.**—Mohair is very lustrous and of a more solid construction than wool. It is stiffer and straighter. Thus it is impossible to tie a knot on a mohair staple, while this may readily be done in wool. Under the microscope the scales of the mohair fibre are found to be bound to the fibre shaft for almost all their length and are not readily observable, while in the typical wool fibre the extremities of the scales stand away from the fibre shaft for a considerable portion of their length. This accounts for much of the lustre of the mohair and in part for the stiffness. Further, mohair, by reason of its diminished scale structure, is not readily felted; it does not readily absorb moisture, nor is it susceptible to influences which cause the fibre to mil-

* For further information on this subject see "The Structure of the Wool Fibre," by Dr. F. H. Bowman, and also "The Microscope, and Its Uses for Textile Purposes," by Dr. T. W. Woodhead in the *Journal of the Huddersfield Textile Society* for 1908-9.

dew. It is exceptionally strong, and weak fibres are seldom to be found. Fabrics made from this material are of excellent draping qualities and wear very cleanly.

(*b*) **Alpaca.**—In alpaca the lustre of mohair is to be noted, but with a closer approximation to wool. Under the microscope it appears equally as scaly as wool, but the scales are held more firmly to the fibre shaft, and they are considerably smoother. This explains its lustre and brightness, and, in conjunction with the fineness of the fibre, its softness also. The fibre is of very solid construction, which causes difficulties in the thorough dyeing. In the natural state alpaca is black, brown, fawn, and white, though the white type is not so white as mohair. The length of the fibre is somewhat remarkable, but it is liable to be deficient in strength.

(*c*) **Camel-hair.**—Camel-hair of the true type is not unlike wool, so far as its scale structure is concerned. It is fairly bright and lustrous, this being, no doubt, due to the large scale structure. Such scales, however, are not well bound down to the fibre shaft. It is not uniform in thickness, thick bristly hair being frequently found. It is somewhat downy in handle, and is not entirely satisfactory so far as strength is concerned.* The fibre length is about 5 inches. In colour it varies considerably, but is usually of a bright fawn. Camel-hair is somewhat short in staple.

(*d*) **Cashmere.**—The cashmere fibre is remarkable for its fineness. The scales are numerous and, as they are fairly firmly fixed to the fibre shaft, favour lustre; but on the other hand their small size and the fineness of the fibre partially minimise this. The slight tendency

* This remark does not apply to the camel-hair used for belting, the bristly material being more particularly employed for this purpose.

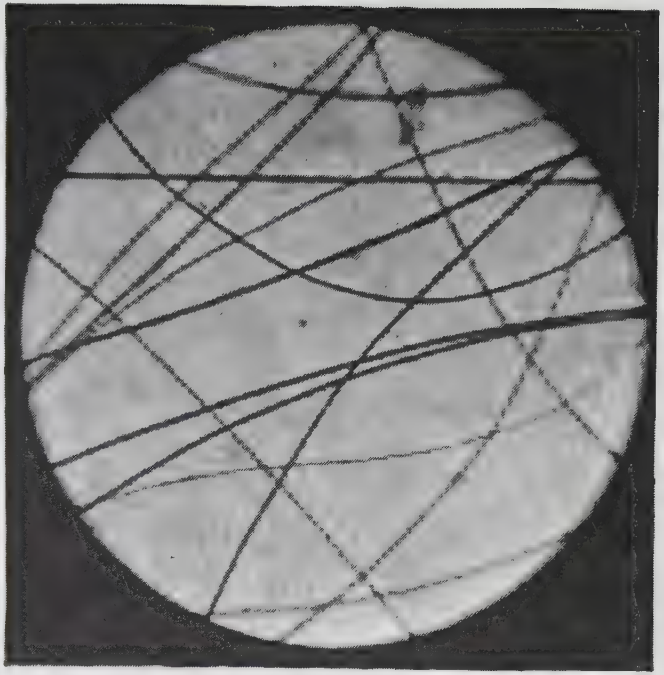


Fig. 53.—Mohair

Fig. 54.—Merino Wool

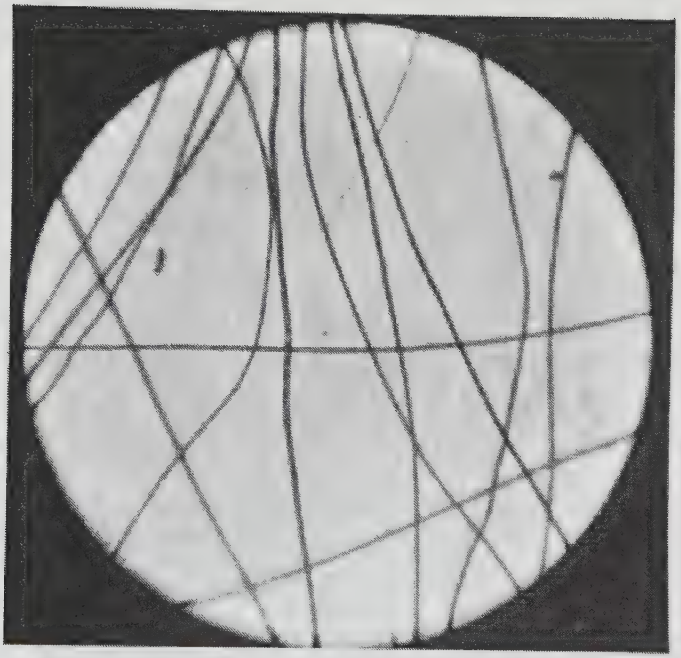


Fig. 55.—Lustre Wool

to curl on the part of the fibre further tends to develop a soft handle.

Natural and Unnatural Impurities in Wool.—Two classes of impurities are present in wool, the natural and the unnatural. The natural impurities are essential to the growth and development of the fibre, and are also necessary to its preservation prior to being subjected to the manufacturing processes. The unnatural impurities found in the fleece are due to the method of feeding the sheep and to its natural habits. They vary both in form and quantity, according to the locality in which the wool has been grown. Of the first class, wool yolk and wool fat may be cited; and in the latter class, sand, dust, dirt, dung, burrs, straw, hard-heads, and twigs.

The natural impurities are usually removed by the process of scouring with heated solution of soap, alkali and water. During the operation of scouring the greater proportion of dust, sand, dung, etc., is also removed, along with the natural grease, by which they are often held in the wool staple.

The other impurities—burrs, straws, twigs, etc.—are usually taken from the wool by being broken up in the various preparing, carding and combing processes. Burrs, however, usually cling tenaciously to the staples, and can only be effectually removed by either special mechanical or chemical treatment.

The Chemical Composition of Wool Impurities.—Much sebaceous matter is essential to ensure the satisfactory growth and development of the wool fibre. This matter may conveniently be considered as coming under two heads: there is first the yolk or suint, which is really the product of "sweat," and

there is the wool fat, which may reasonably be considered as fibre oil. Earthy matters and moisture naturally become added to both of these. Commercially, however, all impurities are referred to as "wool yolk," and such impurities are carefully taken into account in buying wool "in the grease."

The following analysis of a Merino fleece by Chevreul, and quoted by Hummel, Bowman, and others, gives some idea of the relative proportions of the component parts :—

Yolk soluble in cold distilled water .	32.74	per cent.
Earthy matter deposited from above .	26.06	,, ,,
Fatty matter dissolved by alcohol .	8.57	,, ,,
Earthy matter cohering to fat . . .	1.40	,, ,,
Wool fibre	31.23	,, ,,
	100.00	

The commercial allowance or "loss," or "shrinkage," as it is termed, in the various raw wools is approximately as follows :—

English Long Lustre Wools .	16 to 24	per cent.
English Medium . . .	18 ,, 25	,, ,,
English Down . . .	20 ,, 30	,, ,,
Low Cross-bred . . .	18 ,, 26	,, ,,
Medium Cross-bred . .	25 ,, 35	,, ,,
Fine Cross-bred . . .	25 ,, 45	,, ,,
Merino Wools . . .	40 ,, 70	,, ,,

These proportions include all impurities, but do not take into account any variation in the moisture the wools may hold, the standard allowance for which is 16 per cent.

The wool yolk present is soluble in water, and partly so in alcohol. It consists mainly of potassium carbonate, but potassium sulphate and potassium chloride

are also formed in small quantities, along with traces of silica, phosphorus, lime, iron, alumina, etc. The potash salts are of great commercial value, and on this account much attention is now being paid in manufacturing centres to their recovery from the wash water and scouring liquors. The means of effecting this recovery will be dealt with later.

The remaining portion of the wool yolk—the wool fat—is naturally insoluble in water. If this be treated with boiling alcohol it is found to consist of two parts, a fat and an oil. These were classified by Chevreul as "Stearerin" (wool suet) and "Elairerin" (wool oil). These substances can only be partially removed by alkaline reagents, but solvents such as carbon bisulphide are much more thorough in their action on them. Thus it is evident that the fleece of the sheep is not subject to every shower of rain which falls, but is to a certain extent resistant. It is further evident that a certain proportion of these wool fats is essential to the well-being of the fibre, for on their entire removal, either by treatment with alkalies on the emulsion principle, or by solvents, the wool is left somewhat weak, inelastic, and harsh to the hand.

Chemically, the pure wool fibre is composed of a very complex compound known as Keratin, and this, although the composition of various types of wools varies somewhat, is fairly well represented by the following analysis by Mulder:—

Carbon	50.5	per cent.
Hydrogen	6.8	,, ,,
Nitrogen	16.8	,, ,,
Oxygen	20.5	,, ,,
Sulphur	5.4	,, ,,
	100.0	

THE ACTION OF VARIOUS REAGENTS ON WOOL

Water.—Water in its cold or in its tepid state has no injurious influence on the wool fibre. In the case of unmanufactured wool, its effect is to separate the fibres and to cause them to relieve themselves of their impurity. Hot water, however, say beyond 55° C. (130° F.), robs the fibre of its lustre, discolours and weakens it, and causes it to shrink both laterally and transversely. At 130° C. wool may be altogether decomposed in water. In the cleansing of wool, according to the Bradford system, water is the vehicle by which the material and the detergents for scouring are brought into contact, and as such it is extremely handy. To heat the water is essential, the water particles being thereby more finely divided, and its efficiency thereby increased. Heat to excess, however, counteracts this action by causing the wool fats to be dissolved upon the fibre, thereby bringing about its discoloration through the impossibility of removing these in their dissolved state.

For treating wool, pure water is essential, and as all water available for commercial purposes contains impurities—in suspension or in solution—varying in type and quantity according to the source and course from whence it comes, it is necessary, if the best and cheapest results are to be obtained, to subject the water to some form of purification. Excessively "hard" water causes great waste of soap (e.g. 1 degree of hardness will destroy about 1½ lbs. of soap per gallon), and, what is more troublesome still, it gives rise to the production of an insoluble pasty substance, which greatly militates against the action of the scouring agent. The most important reason why Bradford is a wool-treat-

ing centre is because of the purity and convenience of its water supply, the "hardness" not exceeding 4 degrees. Still, it is found extremely advantageous to "soften" even this down to between 1 and 2 degrees of hardness.

Soap.—The action of soap in connection with the scouring of wool is twofold. It first renders the liquid elastic and free, making it more capable of enveloping the fibre; and, secondly, it removes by emulsification—that is, by mechanical combination with small particles—the fatty matter present.*

If the soap be of a satisfactory composition it should not only clean the wool, but it should give to it a certain softness and supplenes of handle, much appreciated by those who can rightly estimate the value of "handle." Many soaps are liable to contain free caustic alkalies which, on contact with the fibre, will harshen and discolour it. Fillings may also be present in the soap in the form of silicate of soda, resin, potato starch, china clay, fuller's earth, French chalk, and so forth, and these are not only useless, but they may do considerable harm. In all cases good standard proprietary soaps of a neutral character (that is, with minimum free alkali—not more than 2 per cent.) are advisable. By this means the alkalinity of the bath may be fairly accurately estimated, and the wool given just the treatment necessary.

Two classes of soap are available, viz. hard soaps made from caustic soda, and soft soaps made from caustic potash, the alkali, in each case, being combined with oils and fats. Soft soap is more often employed in wool washing, as it is more soluble in water and com-

* For further information as to character of impurities, tests, and methods of purification, *see* "The Wool Year-book" (Barker), "Dyeing of Textile Fabrics" (Hummel), and "Wool Dyeing" (Gardner).

posed of much the same substance as the fibre grease, which it is intended to remove. There is also present a small proportion of the glycerine which is considered by some to act as a preservative to the fibre. Soft soaps naturally contain more moisture and there is liable to be more free alkali present than in hard soaps. Upon the whole, there is always the necessity for careful testing and of exercising a wise discretion in selecting a scouring soap.

Alkalies.—The action of alkalies on wool is somewhat severe. A 5 per cent. solution of caustic soda applied with heat will completely dissolve wool in five minutes. Alkalies, however, are necessary in wool scouring to increase the efficiency of the soda or potash as a grease remover; but it should be observed that, even when used in small quantities, their action is slightly injurious to the fibre. Their function in the wash-bowl is to prevent that coalescence of the soap and the grease which would render the bath ineffective. Three alkalies are commonly employed: sodium, potassium and ammonium carbonate. Of these the ammonium carbonate is the best, it being the mildest in action. It is also a volatile alkali, and may on this account be removed in the drying process if any should be left in the wool after washing. Other types are liable to be concentrated on the fibre. Potassium carbonate, sold as "pearl ash," is preferable to sodium carbonate ("soda ash," "pure alkali," and "crystal carbonate" are well-known trade types), it being of the same character as the wool yolk salts, and also more readily soluble in water. It is, however, more costly. Attention should be directed towards soda and potash in their caustic state, for although they are very powerful detergents they should not be used for washing

wool owing to the injury they give rise to as regards appearance, handle, and strength.

That the results of carelessness or ignorance in regard to the operation of wool-scouring are serious is shown unmistakably by data as given below, which has been obtained from actual experiment. And when it is remembered that this process is the first *real* manufacturing process employed on wool, and that any defect produced here tends, in the nature of things, to become aggravated during subsequent treatment, the value of following, instead of some haphazard means, a system such as is suggested on pp. 156 and 157 will be readily appreciated.

EXCESSIVE USE OF SCOURING AGENTS

Effect on Wool (64's Quality Australian Merino)

Type	*Length*	*Strength*	*Handle*
	Ins.		
Fair average sample	2¾	Strong	Very soft
Excessive heat	2¼	Fairly strong	Greasy
Excessive alkali	2⅛	Fairly weak	Harsh
Excessive soap	2¾	Strong	Very soft and slippery
Excessive agitation	1¾	Fairly strong	Fairly harsh
Excessive immersion	2¼	Fairly weak	Fairly soft

Type	*Condition of Staple*	*Colour*	*Loss or Sinkage*
Fair average sample	Free and open	Very white	58 %
Excessive heat	"Stringy"	Yellow and dirty	57 %
Excessive alkali	"Stringy"	Discoloured	59 %
Excessive soap	Free and open	Very white	59 %
Excessive agitation	Very "stringy"	Fairly white	59 %
Excessive immersion	Fairly "stringy"	Fairly yellow	57 %

The action of other reagents is dealt with in list form on pp. 136 and 137, and their application in carbonising, etc., is also described.

DETECTION OF TEXTILE MATERIALS

Characteristics of Fibres as Subjected to Ordinary Microscopical and Chemical Examination

Material	*General Appearance*	*Handle*	*Result when Breaking Fibre*	*Microscopic Appearance*	*Chemical Test*	*Burning Test*
Wool . .	Curly, non-lustrous, short and fine; or Straight, lustrous, long, and fairly coarse. Natural colour: white	Soft (fine wool) to fairly soft (long wool)	Shows good strength and elasticity and tendency to drag before severance	Cylindrical; marked scale structure	Wool, hairs, and silk dissolve readily in cold, concentrated caustic soda, while vegetable fibres remain unchanged	Animal fibres burn with considerable difficulty when free from extraneous grease; flame dies out frequently. Disagreeable odour is emitted, and when burnt residue is in beadlike form
Mohair .	Straight, very lustrous, long, and fairly fine. Natural colour: white	Soft and slippery	Shows considerable strength and elasticity, with breakage like wool	Cylindrical; scale structure not pronounced		
Alpaca .	Straight, lustrous, very long and fairly fine. Natural colour: brown, white, fawn, and black	Soft and downy	Not very elastic and strong; considerable drag when breaking	Scales numerous and smooth; not pronounced	Nitric acid turns wool, hairs, and silk yellow; vegetable fibres are not coloured	
Camel-hair	Somewhat curly, fairly lustrous, long, and fine. Natural colour: brown and fawn	Very soft and downy	Ditto	Scales numerous; fairly smooth; not pronounced		
Cashmere	Very curly, slight lustre, very fine and short. Natural colour: brown and white	Very very soft and downy	Ditto	Scales fairly numerous, but smooth; fairly pronounced		
Silk . .	Dull yellowish or brownish in undegummed state; brilliantly lustrous, yellowish (tussah) or white as degummed	Very soft and slippery	Shows considerable strength and elasticity; breaks with a slight snap	Generally cylindrical; double stranded; very smooth and glossy	Cuprate of ammonium dissolves vegetable fibres; on animal fibres there is no action	
Cotton .	Short, but fairly straight and non-lustrous. Natural colour: white and light brown	Somewhat "dead"; downy	Very strong; not elastic; breaks with a clean snap	Like flattened tube or twisted ribbons	Steeped in dilute sulphuric acid and then dried, cotton may be crushed to powder,	

FLAX . .	Straight, long, and fairly fine; yellowish and lustrous, or (as bleached) white and lustrous	Fairly soft	Ditto	Hollow tube, with markings transverse and lateral, similar to bamboo cane	while animal fibres will not be affected.	Vegetable fibres ignite readily and burn brightly and quickly, leaving no ash
HEMP . .	Fairly lustrous, straight, and long Natural colour: yellowish to brown	Firm and solid	Ditto	Tubular; composed of stiff, cylindrical fibrils	Wool is dyed, silk is stained, while vegetable fibres are unaffected when boiled in a solution of indigo extract in the presence of a little sulphuric acid	
JUTE . .	Ditto	Firm and harsh handling	Ditto	Ditto		
RAMIE . (Rhea or China-grass)	Straight, very long, and lustrous Natural colour: yellow; as decorticated: white	Soft and slippery	Exceptionally strong; similar to above	Composed of small spindle-shaped fibrils		
NOILS .	Lustre and hair: straight and stiff; fairly fine and lustrous—1 inch to 3 inches Fine quality: curly and non-lustrous—½ inch to 1 inch Natural colour: yellowish to white Recombed noils: white and vari-coloured	Fairly soft; hair slippery Very soft and downy	As wool	As wool	After treatment with boiling solution of caustic potash and water, flax turns dark yellow on removal of excess of liquid; cotton remains white or light yellow	
MUNGO .	Short (upwards of ½ inch) and usually fine; not generally lustrous. Contains "thready" pieces	Soft	As wool	As wool, but containing numerous broken fibres and fibres damaged in scale structure		As animal fibres
SHODDY .	One inch or more in length; not usually very fine. Contains part "thready" pieces	Very soft	As wool	Ditto	Cotton and flax turn yellow under influence of sulphuric acid and iodine; hemp is green in colour, and jute yellowish brown	
EXTRACT .	Very short and "thready"; not generally lustrous	Harsh	Weak in strength and elasticity	As above, but showing very pronounced scale structure		

CARBONISING, BLUEING, AND BLEACHING

Carbonising.—In the woollen trade, and also in one section of the worsted trade, considerable advantage is taken of the disintegrating action which acids have upon vegetable fibres. If thoroughly steeped in a dilute solution of sulphuric acid or "oil of vitriol," as it is spoken of in the works, and then dried at a high temperature, the acid is concentrated on the material, and this acts upon the oxygen and hydrogen present in the vegetable fibre (probably in the form of water), thoroughly disintegrating the body of the fibre, leaving it in the form of a blackened carbon mass, which is easily reducible to dust. Such treatment has little or no action upon wool, although under the influence of very strong sulphuric acid the fibre may be disintegrated. Applied reasonably, however, the fibre may be actually strengthened.

This process, which is termed "carbonising" or "extracting," is used in removing the objectionable burr and other vegetable impurity from wool waste and noils in the woollen trade, and also in freeing the wool from the cotton in the case of cotton and wool rags. In the worsted trade, a system of "dry" carbonising, by means of hydrochloric acid gas, is employed. This is in connection with the removal of the cotton thread spun with a wool or mohair thread for strengthening purposes in manufacturing certain "all-wool" goods. A similar process is also used in the woollen rag trade, its value residing in the reduced injury caused to any colouring which may be present in the materials treated.

In the first-mentioned—the "wet" carbonising process—the material is thoroughly cleaned prior to treatment. Steeping is undertaken in a vat containing sul-

phuric acid of 8° Twaddell (1.04 sp. gr.) for forty minutes or more, according to the character and extent of impurity present. After this the acid is allowed to drain away, the material lying on suitable scrays. It is then passed through the hydro-extractor for the removal of all superfluous acid. Drying follows at a temperature varying from 190° F. to 212° F., to effect the concentration of the acid on the vegetable matter, this requiring about twenty minutes or more. Next comes crushing of the charred remains by means of heavily weighted and finely fluted rollers, together with a process of willeying to remove the dust produced. Neutralisation of the residuent acid is then effected in a bath containing soda carbonate; this is followed by ordinary soap-and-water washing, rinsing in water only, then drying.

"Gas" carbonising consists of exposing the material —rags or cloth—to the fumes of hydrochloric acid gas for a few hours in an enclosed chamber. This may be a machine or an ordinary room; in either case a gas-producing apparatus and heating arrangements are necessary adjuncts to the process. Steaming or damping of the fabric is essential prior to this treatment, as by this means is created that affinity between the gas and the vegetable fibre which ultimately results in carbonisation. When thoroughly permeated by the gas, hot air is driven into contact with the material, and this causes concentration of acid according to the principle previously explained. Crushing, neutralisation, washing and drying are later required for the removal of impurities.

In addition to the foregoing, aluminium, magnesium and calcium chloride have been employed with more or less success. The first of these gives certain decided advantages.

Blueing.—The demand by the trade for perfection in colour of textile materials, consequent on the production of goods to be sold either "in the white" or as dyed into pale colours, has resulted in the demand that materials during manufacture shall be perfectly cleaned, and that in cases where naturally "yellowish" wool is employed an attempt should be made artificially to improve its colour. The use of the "backwashing" operation in worsted preparation and "blueing" or "tinting" also, both in woollen and worsted preparatory processes, are the outcome of this. In the case of "blueing," however, it is generally conceded that both the spinning capacity of the fibre and its ultimate fitness for dyeing are lessened, and that when blueing is adopted it is with the idea of effecting a ready sale of the product, and not with any particular regard to the subsequent behaviour and appearance of the material. To "blue" wool is to bring it into contact with a dilute solution of acid colouring matter of a blue, purple or violet tint, the tint thus absorbed being "complementary" to the yellow tint naturally present, and thereby causing a neutral tint to be produced which creates the impression of whiteness. Such tinting, however, is usually proved "fugitive" on contact with light, and it may also be more or less removed by washing. Further, its presence is liable to cause certain harshness of the fibre, though, if well done, this drawback is perhaps negligible. If its removal be attempted, as is sometimes necessary prior to dyeing, much difficulty is often experienced in effecting a regular "stripping," and any irregularity interferes with the production of a uniform shade in the dyed result.

Of the "blues" available—"ultra," "indigo" and "methyl"—the first mentioned is most often employed. Its value lies in the reduced risk of over blueing and

irregular blueing, and in the ease with which the blue may be removed. The two others are very economical, but "spottiness" and a distinct "cast" in the ultimate material may easily result from their use.

Bleaching.—Bleaching gives a more permanent whiteness in colour to wool than "blueing," and on this account it is used in many instances, as, for example, in noils for the hatting trade, where colour is a prime consideration. It has, however, a harshening and weakening action on the fibre; consequently it can only be used on those materials which in character of fibre, and which in respect also of their ultimate form —yarn or cloth—will admit of it. Bleaching is not successfully employed in the worsted trade, save in connection with yarn and cloth. The bleaches used vary in the way in which they act on the fibre. Some reduce its colour pigment, while others destroy this pigment and decolorise the fibre. In the latter case the whiteness obtained is quite permanent. The simplest form of the first-mentioned system of bleaching is that known as "stoving"; it is suitable chiefly for yarn or cloth. It consists of bringing the fumes from a burning bar of sulphur into contact with the material for a period of ten to twelve hours. For effective work, the material must be conveniently placed in an air-tight chamber and moistened. For cloth, a chamber, with mechanically working rollers, is employed, so that the material may be bleached on the continuous principle by a slow passage through the machine.

The action of the sulphur gas (SO_2) and water (H_2O) may be represented as follows:

$SO_2 + H_2O = H_2SO_3$ (sulphurous acid). This tends to become sulphuric acid (H_2SO_4), and in so doing deoxidises the colouring matter present.

After "stoving," most thorough washing is necessary to remove the acid, otherwise weakening of the fibre may result, along with certain injury to any other material with which it may be subsequently placed.

There are many systems of liquid bleaching, the commonest being that in which sulphurous acid is employed. Most satisfactory results, however, are obtained by the hydrogen peroxide treatment, and this is used on a very considerable scale for wools and noils. The process consists of steeping the material in a hydrogen peroxide bath to which has been added a small quantity of strong ammonia. A period of several hours is required for complete decolorisation, after which washing, first in water and sulphuric acid, and later water only, is necessary. If the harshness of the bleached material is pronounced, the wool may be finally "fed" in a soapy water bath. The bleaching action in this case is an oxidising action as against a deoxidising action in the previous case.

Resists: Chlorinated Wool.—Of late there has been a tendency to employ reagents of an interesting character and action for such purposes as "resists," i.e. making the fibre resistant to dyes (usually certain dyes only). This as a rule is effected by treatment with tannic acid. The American coating manufacturers have employed this system to great advantage, but the superior organisation of the Yorkshire colour spinning trade has probably militated against its adoption in this country.

Chlorination of wool, with the object of influencing both the colour-taking and shrinking properties, has also been employed to some extent. Again, in the many and varied combinations of different materials, now so prevalent in the dress goods trade, variation in shrink-

age may be either desirable or undesirable. Under these circumstances the fibre shrinkage may be at least partially controlled, not only by boiling under tension, i.e. "setting," but also by subjecting the material to acid vapours, formaldehyde, etc., There is still quite a field for original research here, which the technical chemistry student will certainly find interesting and probably profitable.

CHAPTER VII

WOOL STEEPING, SCOURING, AND DRYING

The object of wool-scouring is, so far as possible, to remove from the wool both the natural and unnatural impurities, thereby rendering it free and open in staple, and fitted for the subsequent processes through which it has to pass. Scouring should also develop the colour and lustre, and further favour the attainment of a soft handle, which ought to be maintained right through the various processes up to the piece itself. Scouring is certainly one of the most important processes to which wool is submitted, for if it be not performed satisfactorily none of the subsequent operations can be applied to advantage. Even in the wash-bowl itself the disadvantages of a bad scour will be felt, for if the wool be left dirty and greasy there will be difficulties in passing it through the rollers, and difficulties will also be experienced in passing it through the subsequent machines. On the other hand, should the wool be over-scoured, it will prove weak in fibre and will lose a good deal in the subsequent processes. Moreover, the ultimate fabric into which it passes will probably show irregularities in appearance and will be of defective handle and strength.

General Consideration of Wool Scouring.—Before passing on to the details of wool steeping and

Fig. 56

Fig. 57

scouring, a general review of these processes is desirable. The first point to be realised is that the wool yolk itself forms a natural scour, which may either be removed without giving it a chance to act to the fullest extent possible, or may be left to play its part along with the artificial scouring agent added. Upon the whole, its early removal by steeping is to be advocated, as thereby the fibre is undoubtedly cleansed to a very considerable extent. Further, as the wool yolk is in a pure form, it may readily be treated chemically for the extraction of the wash-water by-products, now quite a valuable asset against the cost of scouring.

In the second place, it should be realised that the scouring action is a chemico-physical action; thus it is not true to say that there is no chemical action during scouring, but it is certainly true that the action is largely physical, and that this action is of a most interesting character, including the study of such matters as capillarity, surface tension, pedesis, etc. Thus, as shown in Fig. 56, pure water may be considered to consist of molecules or globules of a spherical form, each globule tending to keep this form. If a tube or wool fibre be placed perpendicularly in water the capillary-attraction causes the surface to take the form shown in Fig. 57.

In Fig. 58 the effect of adding soap to the water is graphically indicated, the surface tension or attraction of globule for globule being modified by the soap.

In Fig. 59 the result of reduced surface tension due to the addition of the soap is indicated; the capillary attraction being much more marked.

In Fig. 60 the possibility of the water and soap globules surrounding the fat and dirt globules on the exterior of the wool fibre is graphically indicated, the reduced surface tension and consequently increased

penetrating power of the liquid in conjunction with heat resulting in the formation of a water, soap, fat and dirt emulsion which is readily got away from the cleansed fibre.

The third point to take into consideration is the handling of the wool during scouring. Not only is the material to be suitably got into the bowl, but it must be passed through the bowl with the least possible felting, and, this accomplished, must be satisfactorily taken out of the bowl. These are operations which require very careful study.

In the fourth place, it must be realised that to insure perfect contact between the scouring agent and the fibre, not only is agitation necessary, but heat also is required. Realising that heat may have a very deleterious action on the wool fibre, it is obvious that there must here be a nice balance between the strength of the scouring agent and the intensity of the heat employed, both being as it were balanced by the natural protective influence of the wool grease itself.

In the fifth place, the economies to be effected without detriment to the wool require careful consideration. There is a difference between true and false economy ; thus, while it may be false economy to employ a cheap scouring agent which jeopardises the wool, it is nevertheless possible, by a careful consideration of all the factors involved, markedly to cheapen the cost of this and subsequent processes.

The Steeping of Wool.—As indicated in the previous chapter, a large proportion of the suint or yolk present in greasy wool is soluble in water. On the other hand, the wool fats are only soluble in such agents as carbon bisulphide, ether, etc., spoken of as the volatile agents, or removable by emulsification by treat-

Fig. 58

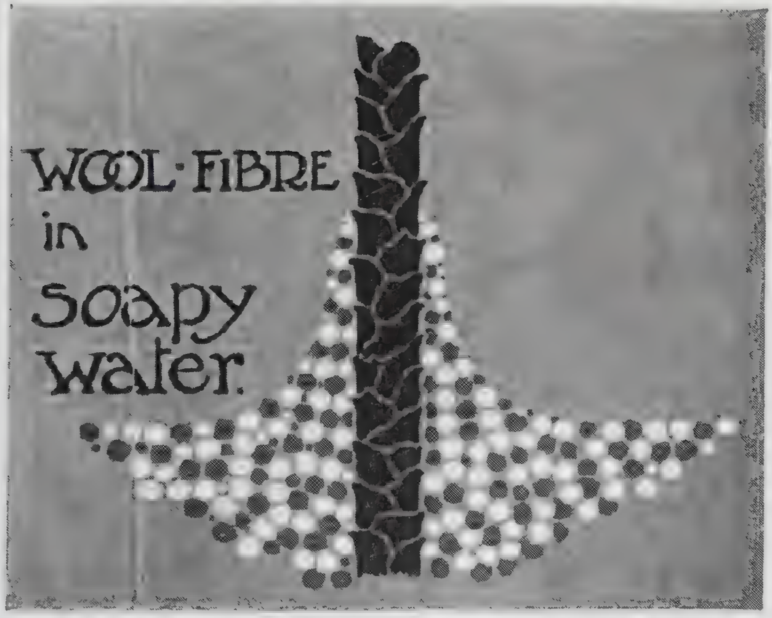


Fig. 59

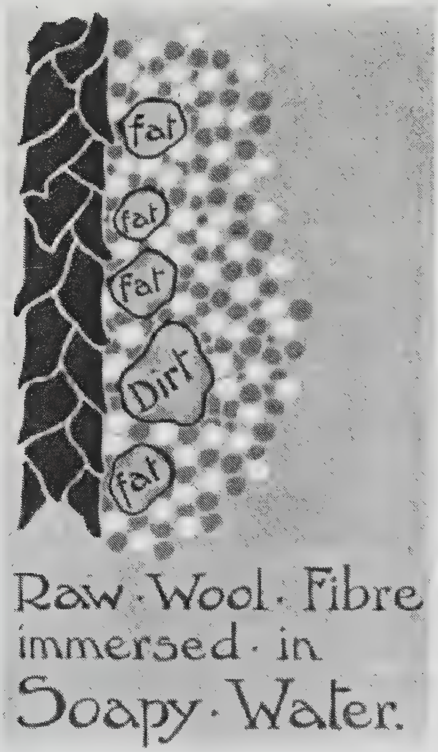


Fig. 60

ment with alkaline detergents. Consequently it is possible, by a system of cold or tepid water steeping, to remove from the greasy wool a great proportion of that impurity which otherwise might necessitate a somewhat severe scouring operation. Again, the suint removable by steeping consists mainly of potash salts from which the potassium carbonate—the most suitable alkali for wool washing—may be extracted, this being worth about £25 per ton. It is therefore evident that, in the case of very dirty, greasy wools, steeping is very advantageous, as thereby all dirt not held in the fleece by grease will be removed prior to the scouring operation proper, thus markedly cheapening this latter process.

Although steeping is by no means unknown in this country, it has never been widely adopted, apparently for the reason that it has not been tried under the circumstances in which its advantages could be fully demonstrated. Possibly the usual method of removing sand, dirt, etc., from the wool by willowing, previous to scouring, also accounts for the little use made of steeping. Willowing, however, is by no means satisfactory from the length of fibre point of view. When steeping has been practised it has too often been carried out with inefficient apparatus, necessitating too much handling of the wool, or treating the wool too freely. On the Continent, however, careful attention has been given to steeping, special machines having been designed as auxiliary to the wool-scouring sets, and this has brought about superior results, both from the points of view of the quality of the material treated and the saving in cost.

From the following description of a representative machine known as "the Maloard," which is made in France, an idea of a satisfactory steeping process will

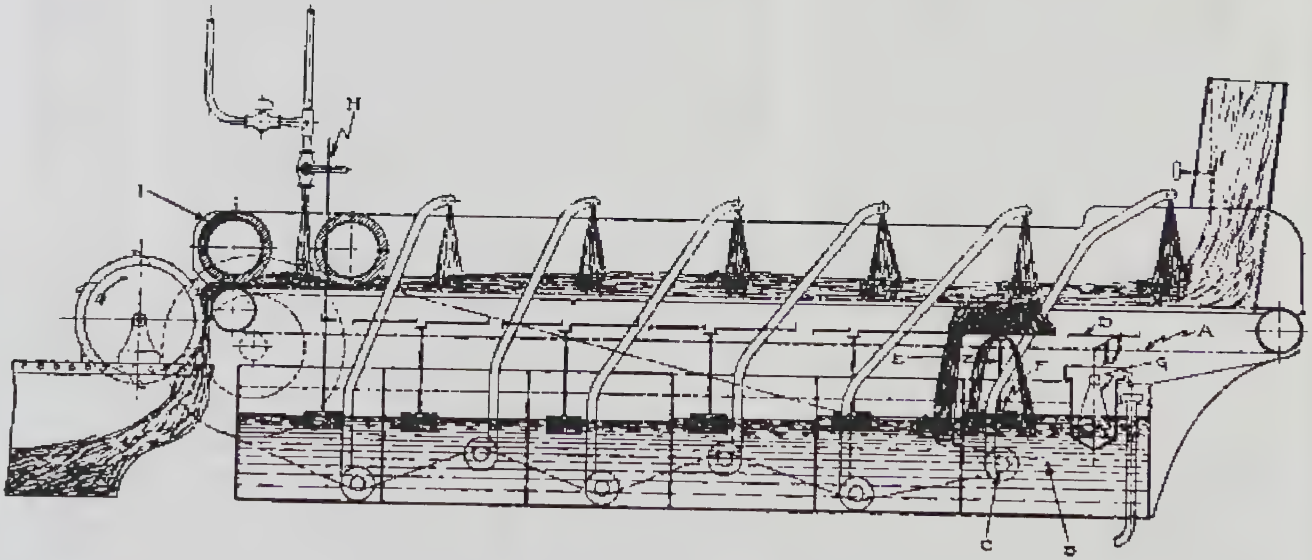


Fig. 61.—The "Maloard" Steeping Bowl

be gained. This arrangement, which is shown in Fig. 61, is largely employed both on the Continent and in America.

The wool is delivered, usually by way of a shoot, on to a slowly moving lattice (A), being arranged in layer form, of a thickness of six inches or more, varying according to its yolky condition. Below the lattice is a series of six compartments (B) containing tepid water, and with each of these is connected a centrifugal pump (C) to effect circulation of the water through a spraying tube on to the wool which is slowly passing. The wool is thoroughly saturated by this means without being agitated or in the least felted. Moreover, as it is repeatedly treated with liquor of increasing cleanness, and finally with pure water, the operation is thorough. After percolating through the wool and removing the potash impurity, the liquor from each sprayer falls on to a special tray (D), which contains two openings—a larger and a smaller—though in the case of the last compartment only one tray opening—a large one—is fitted. In each case the large outlet conveys the liquor from the wool to the tank from which it was pumped; but the smaller—which is fitted with a hinged valve worked by a float (F) in the liquor—conducts a small portion—say one-seventh—into the preceding tank. By this means connection is established between the various bowls, and the pure water supplied at the delivery end of the machine, after being successively passed in to each compartment, is ultimately run off for recovery of the potash. The changing of the liquor is dependent on a hydrometer (G) placed in the compartment at the feed end of the machine, which closes the outlet so long as the liquor is below a desired density. During this time addition of liquor from the preceding compartments is being made to the last compartment through the small tray

openings until a certain level is reached, at which point the tray valve is closed and the water diverted into preceding tanks until each in turn is filled. In the last case the supply from the main (H) is cut off. Continued circulation of liquor and extraction of potash brings about the required density of the liquor in the last compartment. This raises the hydrometer, which in turn releases the outlet by which the contents are led away from the machine. Then with the lowered level of this liquor comes the opening of the tray valve previously referred to; and this creates a passage for liquor from the preceding into the succeeding compartment. In turn the level in the other compartments is similarly influenced, causing ultimately the opening of the pure water supply valve at the end of the machine.

From this description it will be realised that this machine is entirely automatic in action, and that consequently no extra labour is required when it is used in conjunction with a scouring set. It is exceedingly efficient as a steeper, firstly, because of the numerous penetrations of the wool by the water employed, and secondly, owing to the wool being steeped at each stage of its forward movement in water of increased purity. At the delivery point in the machine two nips are given to the wool, one to remove the wash-water liquor prior to the final strain, and the other immediately after to dry the fibre. After this the wool is mechanically conveyed by a feed sheet or beater roller to the first scouring bowl. In the Maloard machine the quantity of water employed in proportion to the wool must be small if the idea is to recover the potash salts, for under these conditions a saturated solution will be obtained. If, however, the removal and not the recovery of the potash salts is the end sought, a much greater quantity

of water may be employed, as this enables the material to be passed more quickly through the machine. Even with the yolkiest wools, however, one of these machines will supply a full scouring set. The recovery of the potash salts, however, is of such prime importance that every attention should be paid to it, for from 1 lb. of liquor charged with impurity to 15° Beaume, or 1.11 sp. gr., as much as 1¾ oz. of potassium carbonate may be obtained after the evaporation of water followed by calcination to remove impurities.

Recovery of Waste Products in Wool Scouring.—Although wool steeping and the recovery of the potash salts from the wash-water products is not largely in vogue in Bradford, still the tendency is towards securing all that may usefully be recovered from the suds or refuse from the actual scouring operation. That this is done is in the first place mainly due to the fact that the treatment of the effluent is legally enforced, and, in the second place, only because such treatment may yield a small profit. Generally speaking, however, the methods employed are unsatisfactory, so that much grease and practically the whole of the valuable potash salts are lost. In the Magma process, which is most commonly in use, the liquors are drained into large tanks, and sulphuric acid added. "Cracking" is by this means effected, the grease thus separated rising to the top, while the heavier impurities fall to the bottom, leaving fairly clean liquor between. From the top of the tanks the greasy liquid is then conducted to filter beds for the removal of superfluous water, after which the remainder, as a pasty mass, is placed in bags and pressed with heat, the oil being thus extracted. The residue from this pressing is a dark coloured cake consisting of a small quantity of

grease, dirt and sand, along with all the potash salts. It is sold very cheaply for manurial purposes. It is somewhat unfortunate that there is no simple, handy and inexpensive process available whereby the whole of the sud constituents may be reclaimed in their separate form.

A very efficient method—the Smith-Leach process—for complete treatment was patented about 1898, and worked for a time on a very large scale. The first cost and running expenses, however, placed it out of court save for those firms dealing with tremendous quantities of very greasy wool. By this treatment pure wool fat, potassium carbonate, and distilled water were obtained, the only residue being a small proportion of sand.

WOOL SCOURING SYSTEMS AND THE PRINCIPLES INVOLVED

The system of wool scouring most commonly in use is that known as the alkaline or emulsion system. Its action depends upon the power possessed by certain alkalies—soda, potash, and ammonia—of emulsifying, in the presence of soap and water, the fatty impurity present in the wool fibre, thereby effecting the removal of this impurity. This removal is accelerated if the liquor be heated, and is further facilitated by a certain amount of agitation of the material during treatment. Much has been done to perfect the necessary mechanical arrangements for working upon this system, and it is now possible to give the fibre, whatever its character or condition may be, just that degree of movement it requires freely to relieve itself of its impurities. Modern scouring sets are also most thoughtfully designed to deal with large quantities of

wools quickly. In the hands of careful and experienced men very satisfactory results are obtained, but the system is not without its element of danger when judged from the standpoint of the quality of the delivered wool. As will be gathered from the preceding chapter, the action of strong alkalies and high temperatures may readily injure the delicate scales of the fibre, or, through concentration in the interior of the fibre, may cause it to become weak and discoloured. Again, too much agitation will have the effect of matting the fibres, this implying considerable breakage and a poor yield of top should the wool subsequently be combed.

The other recognised system is known as the "solvent system," in which such agents as ether, carbon bisulphide, petroleum-benzine, naphtha, alcohol, etc., are employed to dissolve out the oily part of the yolky impurity, thereby liberating the potash salts and any adhering dirt, these being subsequently removed by a simple process of water steeping. This method is at present finding considerable employment in the United States and on the Continent. It is possible that as yet this process has not received the attention from the mechanical standpoint which it merits, for it is certain that, as regards simplicity of action and effect on the material treated, the system upon the whole is superior to the one more generally employed. The chief cause of the diffidence in adopting this process is no doubt the difficulty of handling the highly inflammable solvents. This and other troubles, however, are only such as may be expected in developing a comparatively new method, and must not be considered as insurmountable. The advantages of the system are manifest when it is realised that on the fibre itself the solvents have practically no influence, there being no harshening or discolouring; and, further, that on

account of it being quite feasible to hold the wool and pass the solvent through it, instead of working the wool in the solvent, no matting of the fibre results. In principle, no process could be simpler or more complete, or more economical, as the solvent has simply to be passed through the wool, and when distilled is ready for use again, while the valuable by-products are left as a residue.

Practical Wool Scouring: the Alkaline System.—To effect the complete removal of the impurities found in wool in the shortest possible time and with the least possible injurious action on the wool, it is found desirable to employ three, four or five bowls of large, but varying capacity—the last bowl, for instance, as a rinser being short, while the first bowl, as a steeper, may advisedly be long. Fine wools require larger sets of machinery, the five-bowl sets being successfully adopted for the greasiest and dirtiest merinoes. The following is a description of a three-bowl set, from which the principles of arrangement either for three, four- or five-bowl sets may readily be deduced,

As three bowls only are to be employed, the first bowl cannot be employed as a pure steeper. It must rather be employed as a strong scourer in which a strongly acting artificial scouring agent is employed to "shift" the greasy impurity, while the wool fibre is still protected by the yolk and natural wool fat. Further, to facilitate this, the greatest heat is here employed, say 125° F. The second bowl must be regarded as a scourer of unprotected wool; its scouring strength must then be very materially reduced, say to about one-sixth of that of the first bowl; but soap, as an aid to the action of the scouring agent and as a feeder, may still be present to a marked extent, say about

half as much as in the first bowl. This bowl need not be so long as the first bowl, and the temperature is advisedly kept lower, say 115° F. The third bowl must be considered as a rinser, and as such must contain no alkali at all, but soap of neutralising character, so that any free alkali left in the wool may be rinsed off and neutralised. The soap in this bowl should feed the wool, supplying the place of any natural grease which may have been unavoidably removed in scouring the wool in the first and second bowls. Possibly the best results would accrue by using a large bowl—say 24 feet—but the custom is to employ an 18-ft. bowl. Whatever length is adopted the liquor must be of such a character that the wool leaves it free from pure alkali—for if this be left on the fibre it will ultimately tend to disintegrate it—and with all harshness which may have arisen in the previous severe processes, subdued by the "feeding" of the wool. As there is here no question of loosening the natural wool fats by heat, a lower temperature may be employed, say 110° F. Careful consideration of the list on pp. 156 and 157 will show how these principles are carried out in practice.

Having decided upon the length of bowls to employ, the constitution of the scouring liquors and the temperatures, the next point to consider is the method of presenting the wool to the action of the scouring agent. Here it is evident that two points claim special attention: firstly, the necessity for a thorough penetration of the wool staples by the scouring agent; secondly, the equal necessity for carrying the wool through the bowls with little or no felting action, and the delivery of the wool in a nice open condition. At first sight it would appear that these two necessities are so opposed to one another that to ensure one means an ignoring of the other; but in practice this is not so.

PARTICULARS FOR WOOL SCOURING

Approximate Quantities Used Per Day (10 Hours)

Merino Wool.—Capacity of Set: 20 Packs (4,800 lb.)

Bowl	*Type*	*Length*	*Capacity* *	*Temperature*	*Type of Soap, and Quantity*	*Type of Alkali, and Quantity*	*Immersion*
1	Swing Harrow	30 feet	1,800 galls.	120° F.	125 lb. Soft (Potash) †	35 lb. Potassium Carbonate	3 mins.
2		24 "	1,500 "	115° F.	65 " "	5 " " "	2½ "
3		18 "	1,000 "	110° F.	40 " "	None	2 "
4		12 "	750 "	105° F.	10 " "	None	1½ "

Medium Cross-bred Wool.—Capacity of Set: 24 Packs (5,760 lb.)

Bowl	*Type*	*Length*	*Capacity*	*Temperature*	*Type of Soap, and Quantity*	*Type of Alkali, and Quantity*	*Immersion*
1	Swing Harrow, sometimes Swing Rake, and Three Swing Harrow Bls.	24 feet	1,500 galls.	125° F.	130 lb. Soft (Potash)	35 lb. Potassium Carbonate	2½ mins.
2		18 "	1,000 "	120° F.	65 " "	7 " " "	2 "
3		18 "	1,000 "	115° F.	35 " "	None	2 "
4		12 "	750 "	110° F.	10 " "	None	1½ "

PARTICULARS FOR WOOL SCOURING—*(continued)*

ENGLISH LUSTRE, OR LUSTRE CROSS-BRED WOOL.—CAPACITY OF SET: 28 PACKS (6,720 lb.)

Bowl	*Type*	*Length*	*Capacity*	*Tempera-ture*	*Type of Soap, and Quantity*	*Type of Alkali, and Quantity*	*Immer-sion*
1	Swing Rake	24 feet	1,500 galls.	125° F.	150 lb. Potash or Soda (Hard)	35 lb. Soda Carbonate	2½ mins.
2	Swing Rake	18 „	1,000 „	120° F.	85 „ „	7 „ „ „	2 „
3‡	Swing Rake	18 „	1,000 „	115° F.	10 „ „	None	2 „

* Capacity of bowl generally equals 60 galls. per lineal foot.

† Agents are commonly put in bucketsful when the liquor shows lack of strength, or when the colour of the wool appears less satisfactory. The best arrangement, however, is to bring the liquor up to the required standard at the commencement and afterwards drip the agents continuously into the bowl to keep the suds up to the required degree of efficiency. This may be conveniently done by pipe arrangements from the soap and alkali tanks. Or pumping of the agents into the bowl may be done at intervals.

‡ A fourth bowl—a 12-ft. machine—is sometimes used here.

It is not at this stage desirable to go into the various types of early scouring machines in which any and every kind of action has been tried, but rather to emphasise the principle upon which the best wool scouring is based. This principle is that wool naturally opens out when placed in water, this being due to the elimination of surface tension. If, then, the wool is naturally opened out in the scouring liquor, is partially carried forward by the flow of the liquor, and this movement is gently aided by the action of suitably worked forks, then it will be evident that a satisfactory progression of the wool will be ensured. The only further difficulty at this stage is taking the wool out of one bowl and feeding it into the next. This is best effected by presenting the wool to the squeezing rollers placed at the end of the bowl, so far as possible, just as it has been floated through the bowl. To ensure this, it is necessary practically to float the wool as close to the nip as possible, and then further to aid its passage forward by some special feed action, such as McNaught's "auxiliary rake feed," whereby a level continuous feed to the rollers is ensured. This seems very simple, but so closely are the chemical, physical, and mechanical problems here at issue interwoven that failure of the one may mean the failure of the other. If the chemico-physical action of the scouring bath has failed to remove a sufficient amount of the wool fat, the squeezing rollers will refuse to take the wool presented to them. Thus, although it may be wise to lay down the rule, "as little agitation in the bath as possible," it may, nevertheless, be absolutely necessary, in dealing with certain types of wool, to provide for agitation of the wool in its passage through the scouring liquor. Several styles of rake action are placed on the market with this idea in view.

Having floated the wool out of the first machine, it is now fed, without disturbance, by means of a travelling lattice, into the second machine. The feed to all these machines consists of a travelling lattice, upon which the wool is evenly spread, a pair of taking-in rollers, and an immersing apparatus, whereby the wool on emerging from the taking-in rollers is immediately sprayed and well immersed in the liquor.

It is somewhat remarkable to note that, even after the wool has passed through five bowls, there is still a considerable quantity of dirt left in the staples, which the carding or preparing operations show up. This is usually removed in the back-washing operation, which follows carding or preparing. The presence of this dirt renders it very undesirable to give the wool a "wet nip" on its passage from even the last scouring bowl, as a "wet nip" is usually considered to nip the remaining dirt into the fibre, and thus to spoil the colour of the wool.

It will at once be realised that the method of dealing with the scouring liquors for a set of bowls will be very different from the method adopted in the early days of the industry, when one bowl only was employed, and the wool simply forked about until it was considered clean. Roughly, there are three main points here to be taken into consideration: firstly, the getting of the liquor into the bowl, and into a fit state for scouring; secondly, suitable arrangements whereby the liquor in the bowl shall be used to the greatest advantage; thirdly, the clearing of the bowls of the sud and of the settling products.

Suitably to prepare the liquor, water and steam must be carried to the bowl so that water of the required heat may readily be obtained. In close proximity to the bowls two tanks should be arranged, one for soap liquor and the other for alkali. If these can

be fixed above the level of the scouring bowl, then pipes may be laid to connect them up, and a gravity feed, allowing a gradual introduction of the scouring agent during the actual operation, may be arranged.

The control of the liquors during the actual operation of scouring has claimed the attention of the makers of scouring machines for the last fifty years. The main points to be observed are, firstly, to make suitable arrangements for the dirt and grit from the wool to fall, as it were, out of the scouring liquor; secondly, to remove any spent or dirty scum; and, thirdly, to keep up a flow of the active scouring liquor. The first object is attained by means of the false bottom of the wool trough placed inside the bowl, in conjunction with the shape of the bowl. This is further ensured by the settling tank, into which the carrying liquor, which passes with the wool up to the nip of the rollers, falls, there to be allowed to stand until impurities rise or settle out of it, when it is pumped back as a feeding spray, fresh scouring liquor being added to it as previously described. The third object is attained by this pumping of the liquor from the settling tank into the main bowl, and possibly by the forking of the wool forward.

The design of the scouring bowl, to facilitate the running out of the scouring liquor and the removal of solid impurities, is worthy of most careful consideration. Instances are on record in which the production of a scouring set has been seriously limited by the size of the drain for carrying off the waste liquors. It is equally important to be able thoroughly to clean the machines as expeditiously as possible. In Figs. 62 and 63 the best style of machine is illustrated, in which reasonable consideration is given to these points, and a representative system of drainage is also shown in Fig. 64.

Having dealt with a set of wool-scouring machines,

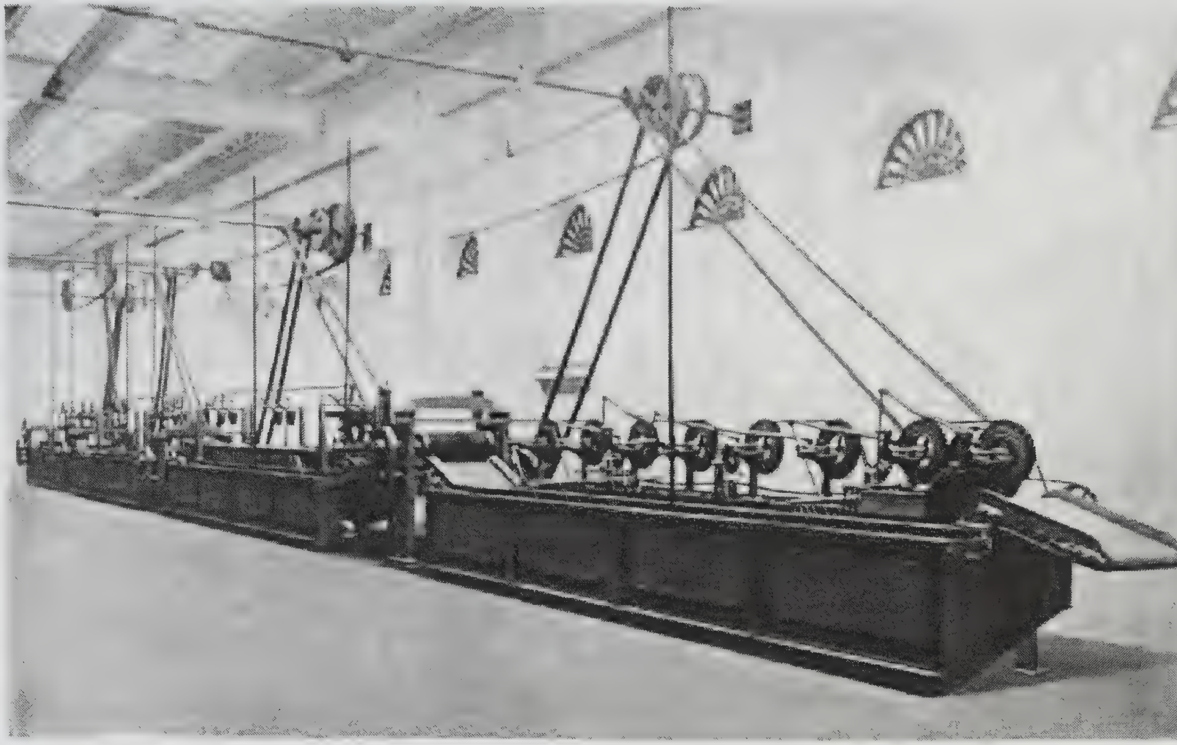


Fig. 62.—Four-bowl Scouring Set for Merino Wool

1st Bowl, Swing Rake, 24 feet; 2nd, 3rd and 4th, Swing Harrow, 24 feet, 18 feet, and 12 feet respectively

attention may now be turned to the detailed construction and arrangements of the bowl.

The bottom of the bowl proper generally slopes, as in the case of Messrs. McNaught's and Messrs. Petrie's (both of Rochdale) machines; or it may be circular, as in Messrs. Dawson's (of Milnrow) bowl. In such case, dirty impurity, once removed, settles to a point farthest away from the wool, from which it may be cleared by steam, or, as in the case of Dawson's circular-shaped bowl, thorough removal may be facilitated by means of a plate mounted on a shaft running the length of the bowl and oscillated by hand from the feed end. The first two (or three) bowls are, as a rule, fitted with a special settling tank, by which the dirty liquor, delivered by way of the nip, may, on standing for a while, free itself from its impurities (the dirt falling to the bottom and the grease rising to the top of the sud) and admit of the clearer liquor being carried back to the bowl, where scouring is to be done by means of a centrifugal pump fixed in a suitable position at the feed end. In the McNaught bowl connection to this tank is by way of a channel from the trough under the nip; in the Petrie, the centrifugal pump may be employed as an alternative if desired. For the longer qualities and cleaner wools, in the machine as made specially for this work by Messrs. Petrie, washing takes place in the big bowl. It contains, however, a perforated bottom to control dirty impurity, and, if desired, there may also be fitted with it a side settling tank. This form of bowl enables big quantities of material to be handled, and it also admits of a dry nip being given, the wool being brought up to the rollers by a special slide of toothed bars, which are traversed in sets by cranks. This arrangement is used instead of the system of floating the wool to the nip through

the agency of forks, and a special chute arrangement, which is part of the end of the bowl, and is necessary in the case of wools, which, if not fed to the nip in open condition, will readily mat.

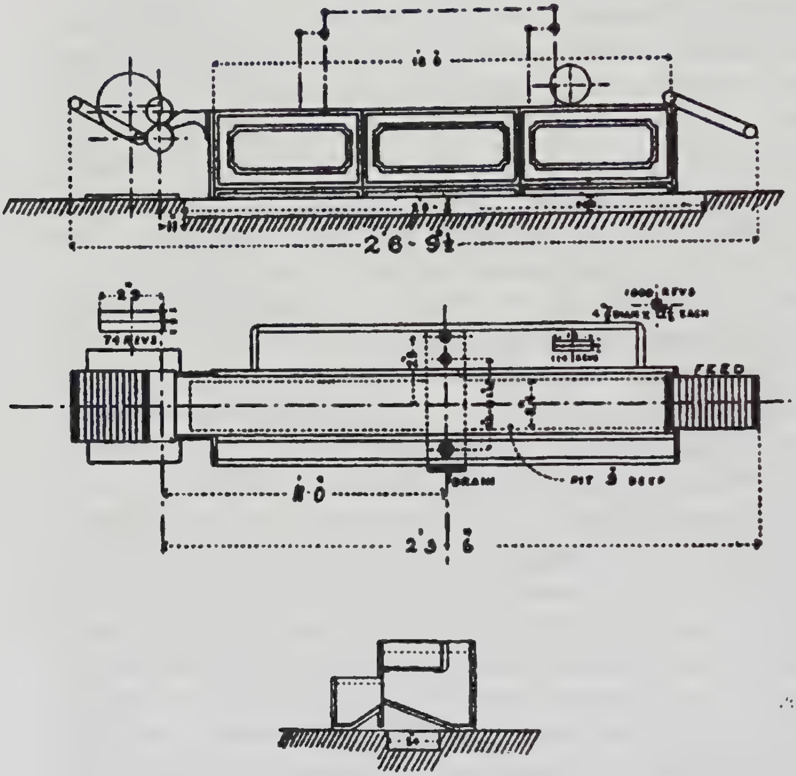


Fig. 63.—Plan, Elevation and Section of McNaught's Washing Machine

To the second and succeeding bowls pump transmitters and pipe connections are fitted so as to provide for the changing of the liquors. As the wool, on passing through the later bowls (the third and fourth), is in a fair state of cleanliness, the liquor used

is by no means unsuitable for treatment of the dirtiest wool; therefore, as such procedure means considerable economy, it is usual to drain away the contents of the first bowl only, filling this with the suds from the preceding machines, these being afterwards raised to the required standard of scouring by the addition of agents. Clean water is, of course, added to the last bowl.

Rake Motions.—Propulsion of the wool through the machines, or agitation, is effected by either the "swing-rake" or "swing-harrow" mechanism, or by a combination of both. The first-mentioned (first bowl, Fig. 62) is for the lower qualities, which do not readily mat. The movement given to the wool by this method is great, but it has the advantage of increasing the turn-off. Forks or rakes of brass (hollowed) are mounted on an upright lever, this being connected to a shorter and more horizontally working link, fixed in turn to a standard. For each rake a short crank arm is driven by bevel gear; this is linked up to the rake stem, and thus, on the revolution of the crank, the rake is made to follow an elliptical path sufficient to propel wool. By simple adjustment the forks may be worked in unison, or they may be alternately worked, one up while the next is in the liquor, in this way giving useful modification of treatment according to the condition of the material.

In the "swing-harrow" (second and subsequent bowls, Fig. 62) the rakes are fixed transversely with the machine to two long arms of tubing running parallel with it. The connection is then established between the frame of forks and two T-levers fixed on vertical standards, the levers being also fixed together. The T-levers are weighted at their extremities to preserve a balance; one of these is linked to a

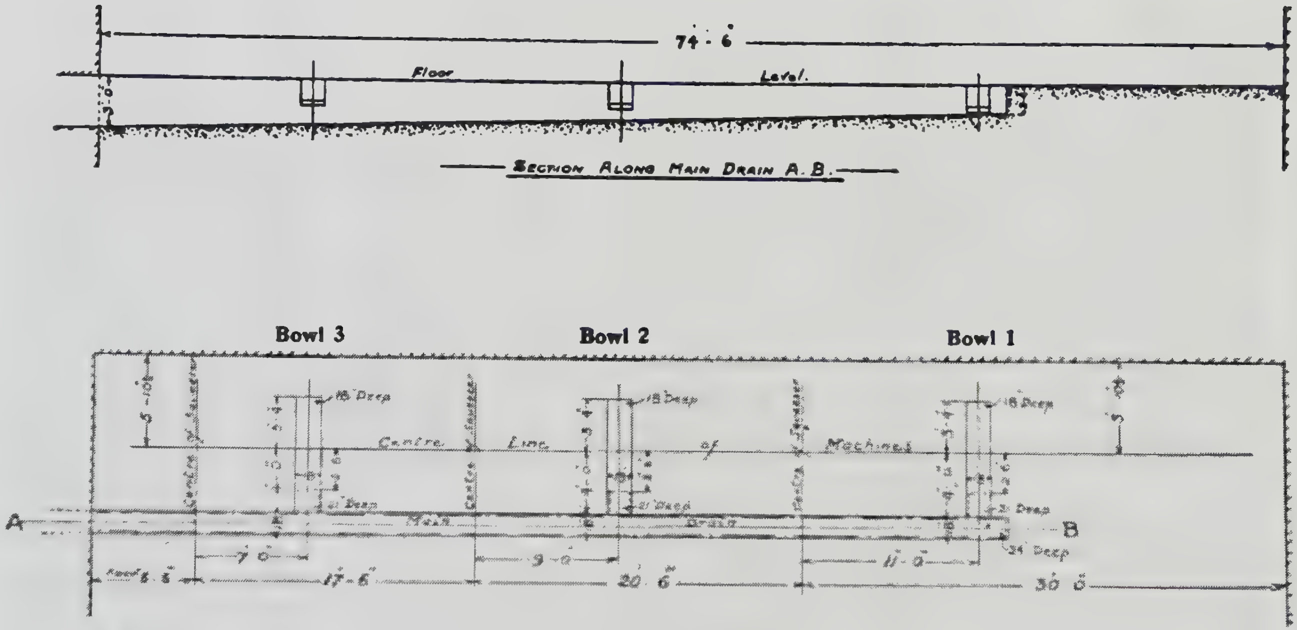


Fig. 64.—Plan of Drainage Connections for a McNaught Washer

horizontal lever centred at one end, which is given a rising and lowering movement through the action of a cam on the main shaft. By this means the harrow is made to follow one part of its course.

To the harrow also a horizontal rod is fixed by which it receives backward and forward action. This rod is connected to a slotted lever, centred at its upper extremity, in which works a crank pin driven from the cam shaft before referred to. The combined movement thus given is circular, and for the forward movement (when in the sud) it is slow, but on being lifted clear of the sud for returning, it moves the harrow quickly. As all the rakes in this system strike the liquor together and have slow action, the minimum disturbance to both wool and sud is caused, a condition absolutely vital to its freeness and openness if fine material be treated. The same movement is also used on a perforated box fixed to the harrow, by which the wool is submerged immediately on entering the bowl.

In Fig. 65, which shows a machine of this type, the wool is fed by hand on to the feed lattice A. Immediately the wool is pressed down into the sud by means of a "ducker" B, thus preventing the wool from riding on the water. To reach this point it is assisted by the flush of water entering the tank at C, which also gives it the necessary impetus to reach the forks D. The forks here are arranged on the harrow system, which implies that the forks are in rows and fastened on to laths E (at equal distances), which laths run the whole length of the machine. These are moved in a regular path as follows:

First Movement.—Down into the sud.

Second Movement.—Forward towards the delivery rollers a distance of about one foot, carrying the wool in the bowl with them.

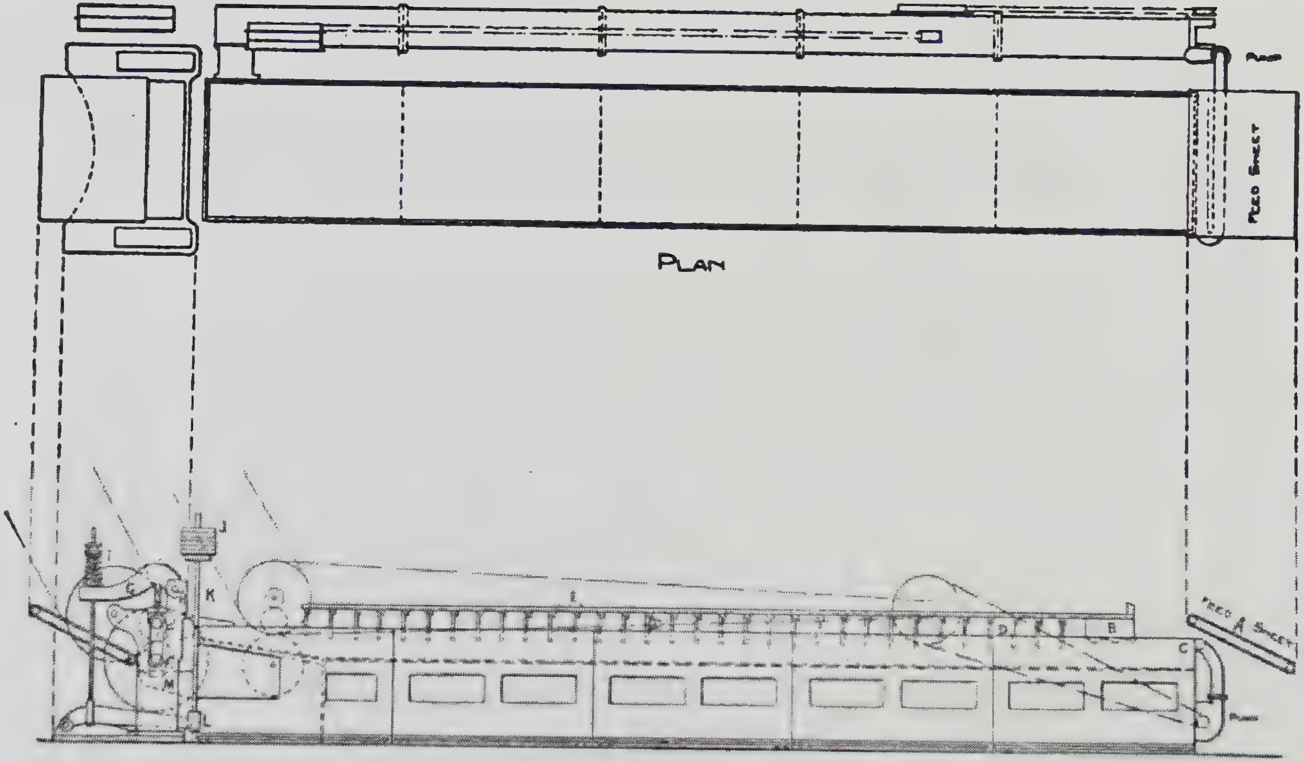


Fig. 65.—Harrow Washing Machine

Third Movement.—Upward and out of the sud.

Fourth Movement.—Backward until they are in their original position.

Thus they propel forward the wool until the delivery rollers are reached. To lift the wool from the bottom of the tank the tank bottom is inclined and consequently the forks are shortened at this point. The wool enters the squeeze rollers F in a very wet condition, water from the tank flowing with it. This is designed to give the wool a wet nip. The squeeze rollers are weighted by a strong pressure lever G having its fulcrum at H. Power is applied at I by means of a strong spring. Weights J are placed on the rod K which cause a depression to act at L, and these, though small, cause considerable pressure on the squeeze rollers. The waste water which is always very dirty, is allowed to fall into a settling tank M instead of being returned to the washbowl again. The sand and dirt are allowed to settle in this tank and the water, now clear, is pumped back again into the bowl at the feed end of the machine. After settling, however, the water is heated to the required temperature, making the addition of steam to the bowl unnecessary.

Arrangement of Sets.—For medium and medium-to-fine wools an auxiliary rake is sometimes fitted to the machine to ensure a regular feed to the squeezing rollers. This motion—put on McNaught's machine—is also of great value, for its movement most markedly aids that of the main harrow. The combined rake and harrow arrangement is used frequently, as is found in Messrs. Dawson's sets of machines. The action in this case will be realised from the description already given. In other cases, one or two of the "swing-rake" bowls precede those of the "swing-harrow" type, this arrangement being adopted to favour increased output at that period of

the operation when the wool, being greasy, is less liable to be injured by the severer action of the rakes.

The "Nip."—The squeeze-head or "nip" of the scouring bowl is a part of no small importance. It is required not only thoroughly to remove superfluous moisture from the wool, and by this means reduce the time necessary for drying, but it must also leave the wool free and unbroken. For the purpose of efficiency, the bottom roller is of steel or cast iron, and sometimes is brass-covered; the top one is of iron and generally wrapped with hog-wool slubbing, or, as in Petrie's special squeeze-head, covered with compressed cloth to prevent the fibres being cut. For ordinary wool the bottom roller is plain-faced, but for exceptionally greasy wools, which, particularly in the first bowl, tend to stick at the nip through slipping on the roller, a slight marking or dimpling is applied to it. The application of weight, as the illustration well shows, is by means of compound leverage; with this as much as eight tons pressure may be applied if desired. An indicator for this is supplied on the Petrie machine. A danger is found in that through this weight "flats" may be produced on the upper roller through neglect when the machine is standing; but as a means of avoiding this by supplying a handy method of removing the weight, McNaught's worm and pinion arrangement, actuated by a handle, is extremely serviceable.

A somewhat novel departure in wool-scouring machinery has been placed upon the market by Messrs. W. A. Layland and Co. The bowl employed has a false bottom, while underneath is a division carried lengthwise and also slantingwise to allow for the settling liquors. Two partitions, forming three compartments in the bowl, are also placed crosswise to aid in the settling

process. The dirty liquors coming from the squeezing head run into the first compartment, the sand and dirt falling to the bottom. Constant addition causes an overflow of the upper part of the liquor, which more or less consists of greasy matter, and this in the second compartment is removed from the surface by a special overflow valve. The connection with the third compartment is effected through an opening in the bottom of the partition, the freer liquid by this means being drained off. This, after further settling, is carried back to the wool by a rotary pump. The agitating mechanism is on the parallel rake system, but in this case motion is conveyed from below, an arrangement which at least admits all the light possible and in some respects perhaps results in freer access to the bowl. The rakes are borne by transversely and laterally arranged arms, and are worked by a series of cranks, cams, and the connecting links, the movement obtained being similar to that ordinarily employed. For increased output, the width of the bowl may reach 4 feet, but such a width is not altogether satisfactory, owing to the difficulty of giving an effective nip with the long rollers necessary.

The Solvent System.—An apparatus, to be successful on this system, must provide for the following: (*a*) The thorough removal of the greasy impurities, with little or no agitation of the wool and no discoloration of fibre; (*b*) simple action and, if possible, continuity of action; (*c*) absolute safety as regards both control of the volatile liquid and of the vapour from such liquid. It is with reference to the two last-mentioned conditions that the arrangements so far designed have proved somewhat ineffective. At the same time, it must be realised that the use of carbon bisulphide in the

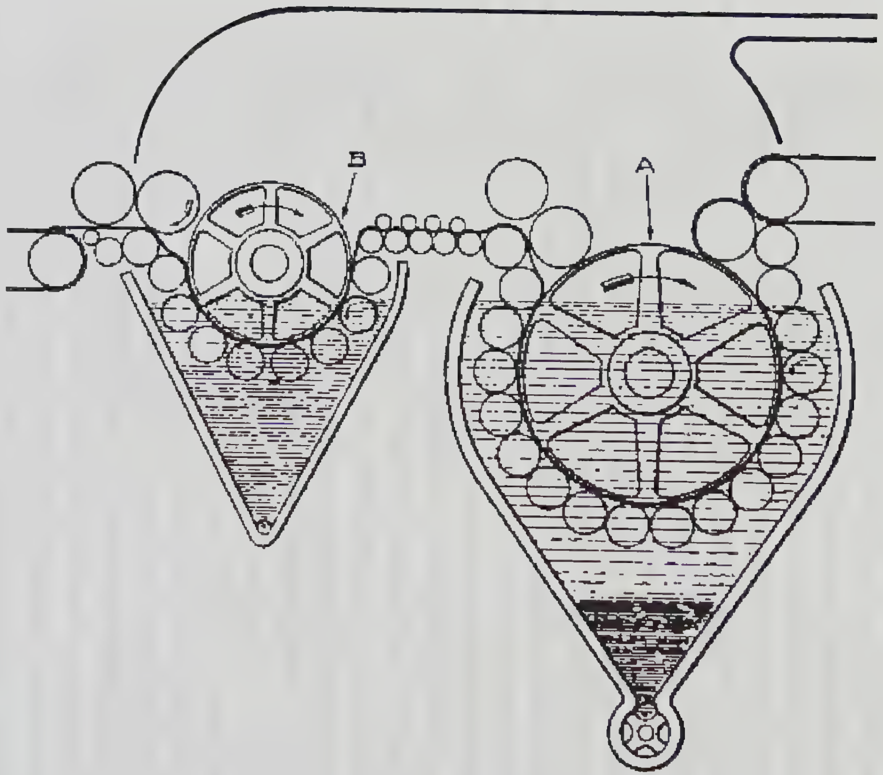


Fig. 66.—The "Burnell" Wool Scouring Machine

presence of heat is liable to discolour the fibre. Prior to 1888 many attempts were made to design satisfactory machines, but it was not until 1909, when a useful machine was placed on the market by Messrs. G. and A. Burnell, that the practical possibilities of this system were realised. This machine (Fig. 66) consisted of two V-shaped tanks, a larger and a smaller. The larger was charged with the solvent, petroleum benzine, while the latter was charged with hot water to release the potash salts and to evaporate any remaining solvent. Revolving in each tank was a large cylinder (A and B), while forming a series of nips with this cylinder were a number of smaller cylinders. The wool was fed from an ordinary apron through feed rollers and then successively squeezed and released in the first tank—a process which quickened the separation of impurities. The heavier of these dropped to the bottom of the V, and from thence were readily removed. To prevent loss of solvent while this was being done, water (heavier than benzine) was run into the bottom of the vessel, being maintained at a fixed level. A thorough action of the benzine on the wool was ensured by conducting the benzine into the first bowl at its delivery end. Having passed through the first bowl, the wool was conducted to the second bowl, in which it was cleared of all the sand, grease, etc., while any remaining benzine was vaporised. Purification of the solvent agents was effected by distillation in separate tanks, by which means the agent was used over and over again. The potash liquor was subjected to a process of evaporation and calcination for the recovery of the potash salts. To prevent explosion or discomfiture of the attendants through the escape of vapours, an iron hood was fitted over the upper part of the machine; the top portion of this was drawn into a tube, through which

suction induced the gases (which otherwise might find exit from the sides of the machine) to pass into the condenser.

As regards output, the machine equalled that of the emulsion system as generally employed. Possibly some slight matting of the fibres resulted from the nipping, while the high temperature (170° F. and over) of the water in the second bath possibly hardened the fibre. This machine, however, is interesting from its being the representative machine for continuity of action.

Maertens' Machine.—The modern application of the system of solvent scouring is represented by an apparatus patented by Mr. E. Maertens, of Rhode Island, U.S.A., which, it is stated, is now in use on 250,000 lb. of greasy wool per day at Arlington Mills, Lawrence, Mass., and also at Verviers in Belgium. It is interesting to note that in 1909 an installation was made in a Bradford mill. The fact that the quantities of wool mentioned are handled, speaks well for the efficiency and economy of the process; on the other hand, it is difficult to see how, with the costly and complex equipment necessary, it can ever attain wide adoption, especially among the smaller firms.

The following description and sketch plans (Fig. 67), extracted from an article by Mr. William Naylor, F.C.S., in the *Textile Recorder*, will give a general idea of its action.

"Referring to sketch plan of the plant, drawn to show the principle rather than the actual location of the parts in entirety, the wool is introduced first into vertical kiers, or digesters, of which there are four, worked in pairs—A with B and C with D. The tops or mouths only of these digesters protrude through the floor of the room above them. The digesters are charged by hand, each taking 3,000 lb. per charge.

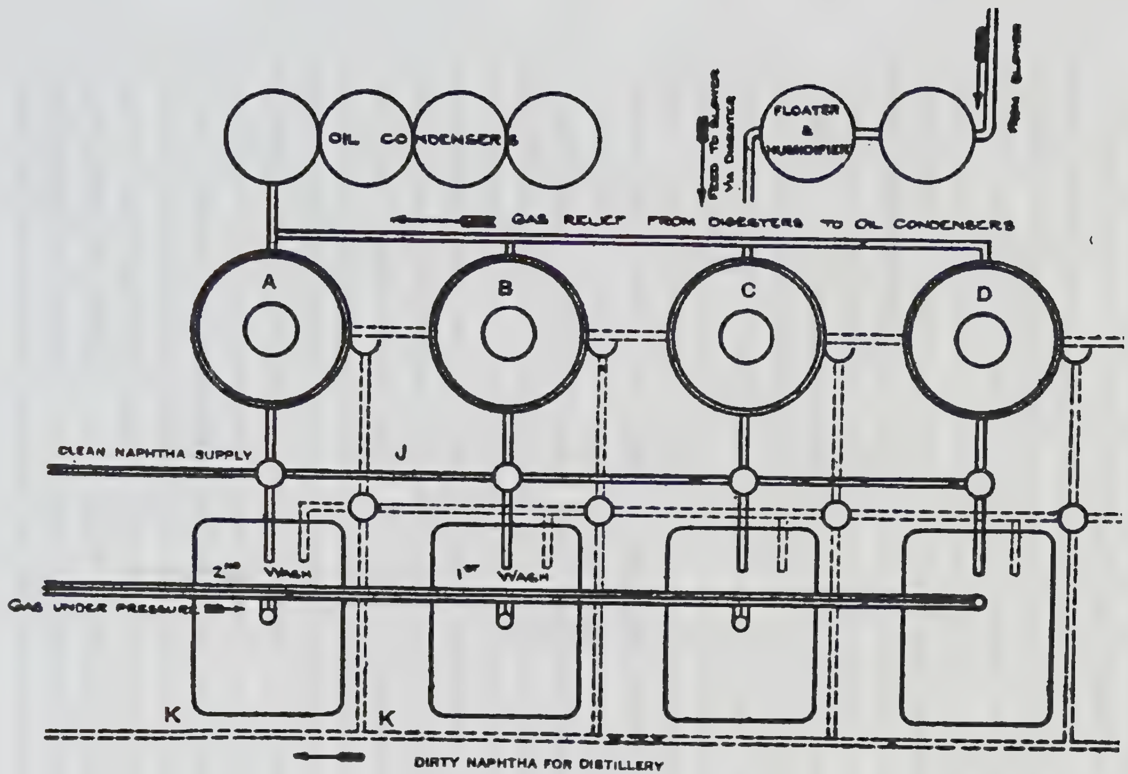


Fig. 67.—The Maertens Wool Degreasing Plant

When full, the digesters, provided with gas-tight joints, are screwed down, a flush of naphtha is injected through a side pipe at the top of the digester, but in the room below, so as to spray over the wool and pass through it, bearing away the grease.

"It will be seen, therefore, that the naphtha feed resembles in some measure the traverse of high pressure kier liquor, being propelled as it is by a pressure of gas behind, except that, instead of traversing the same kier continually, it passes on to the next kier, subject to further remark. For complete cleansing of each batch of wool three of the flushings are required, but the operations are so arranged that the solvent always goes away fully charged with grease, and that the last flush is always made with clean solvent. Assuming the digesters A and B to be newly charged with greasy wool, a flush of naphtha is injected from the reservoir—naphtha which has already been used twice over. The injection is of the well-known dip-pipe and compressed-gas type, like a Shone's ejector or laboratory wash bottle, but the gas used is inert and non-inflammable. A connected delivery from the reservoir to kiers is shown by the single line J, the kier A being flushed first with naphtha already fouled, and the dirty naphtha being returned by K and K to the distillery for the separation of the grease and naphtha. Kier A is next flushed by solvent, having been used only once; but this, instead of being returned to the distillery, is used to flush kier B, the same continuous gas pressure propelling it, following which it is returned to the distillery. The next flush for A is clean naphtha, either from distillery direct or from a clean reservoir, and this, after being passed through B, is returned to reservoir, or to one reserved for solvents of its special degree of grease content. Kier B is finally flushed with clean

naphtha, completing batches in A and B kiers, and so on *ad infinitum.* The various valves and by-passes to effect these movements are considerable in number.

"Nevertheless, they are easily controlled in practice, each series of pipes being painted a distinctive colour and the valves marked unmistakably. In addition, the particular flush passing through a digester can be recognised at once in the gauge glass. They are right after each other, and the line of demarcation is plainly visible all down the glass. Four-way valves or passes are shown by small circles in the sketch plan, three-way by the semicircles.

"Any digester can be connected with any reservoir, or with the clean naphtha supply, or with the distillery dirty discharge. The digesters are on the ground floor, accessible from every point, but the reservoirs are in subterranean vaults, buried in sand, except for the protruding valves, gauge glasses, and fittings.

"After the third flushing the digesters are left (their contents saturated with adherent solvent) under a gas pressure sufficient to overcome the lift, and gas itself saturated with solvent vapour. Such a condition of affairs is met in a very creditable manner. The gas pressure is released through oil condensers, or scrubbers, passing from thence to the gas holder, from which the compressor draws its supply, the oil condensers sending their saturated charges periodically to the distillery for the liberation of absorbed solvent. The covers are not removed from the digesters until they have been swept out by a current of warm, moist air for a considerable period of time. Humidity and temperature of this air are nicely regulated to ensure the abstraction of solvent vapour only, without affecting the natural hygroscopic condition of the wool. The moist, warm air is propelled, by means of a Root's

blower, through an adjustable humidifier, and after passing through the digester, forms the feed to the blower. But between the blower and the humidifier is a condenser for the abstraction of solvent vapour, and, unavoidably, some water vapour. By this arrangement the same current of air is used constantly over and over again, alternately absorbing and depositing naphtha vapour in its circuit, its load as it passes any point between the digester and the condenser growing less each time. Every trace of vapour is recovered from the wool by this method, following which the digesters are opened and degreased wool discharged, still containing all the potash and much of the dirt.

" Live steam is used in the distillery for driving off the solvent, and is recovered without torrefying the resultant grease. A mixture of naphtha and water naturally forms the distillate, and for purpose of drawing off at frequent intervals, the distillate receivers are provided with numerous dip pipes of different lengths, which permit the withdrawal of either solvent or water at almost any point.

" A very easy matter is the washing of the wool after degreasing; in fact, the wool requires no washing—simply a rinsing. This operation is startling to one who has been accustomed to see the laborious process of a scouring machine. A simple rinse through cold water changes the colour from brown to white, the water just racing through as through old hay. The rinsing water contains all the potash, too, from which it can be recovered by evaporation."

WOOL DRYING

General Considerations.—Although wool is very thoroughly squeezed on leaving the scouring bowl,

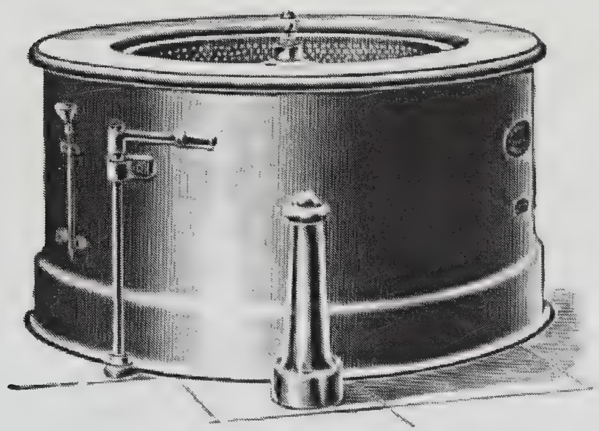


Fig. 68.—Hydro-Extractor or "Whuzzer"

it is not possible by this means to free it from superfluous moisture. To increase the efficiency of the nip, rollers of decreased diameter have been tried; but owing to the difficulty of conducting the wool up to them, and also to the fact that small rollers imply severer treatment, this method of wool drying has not been found satisfactory. The moisture present on delivery from the scouring bowl varies from about 50 per cent. in the case of Merino to about 40 per cent. in the case of Cross-bred and Lustre wools. In Merino wools it is found that the moisture helps to control the fibre in the subsequent processes, overcoming electrification and to some extent the natural curliness present. Consequently it is not customary to carry these wools through a special drying operation, but to effect the drying necessary in transferring the wool from the wash-bowl to the card, which is usually accomplished by automatic conveyers. With the longer qualities of wool, however, and also with hair, careful drying to a point within, say, 16 per cent. of moisture is desirable, for if the wool be too damp the fibres "sulk" or lie lifelessly in the machines and thereby cause considerable trouble. The method generally employed for drying is that in which a large volume of heated air is brought into contact with the wool. An alternative system to this is available in which centrifugal force is employed. In this case the wool is placed in the hydro-extractor (Fig. 68), or "whuzzer." This is really a revolving cage (running at, say, 1,100 revolutions a minute), and the wool placed in it parts with its moisture much the same as would wet rags whirled round and round on the end of a piece of string. Though good in principle, this method is inconvenient when dealing with large quantities of wool, for the machine employed is intermittent in action, and, further, is not capable of extracting more than, say,

70 per cent. of the moisture present. For small lots, for yarns, and also in connection with carbonising, this, however, is a serviceable method. The machine itself is very simple, consisting of a wirework cage mounted in such a way that it can be revolved at a speed of from one to two thousand revolutions per minute. Suitable pipes and an outer covering are arranged so that the liquors thrown off are collected and drained away. The cage itself is arranged on a self-balancing principle, and may be revolved by a pulley and belt from the mill shafting, or driven independently by steam or electricity. On the material being placed inside the cage and the machine set in action, the material, by centrifugal force, is driven to the sides of the cage and there held while the free water is thrown off and collected as already described. This machine, however, must only be considered as a first or preliminary dryer.

In hot-air drying two methods are in general use: the first, "hand," or rather "table," drying, and the second "machine" drying. The former, although relatively unsatisfactory as regards quantity of wool treated for the space occupied, and also from the point of view of labour required and the turn-off, is the better arrangement from the standpoint of the condition of the material after treatment. The reason for this is that heat is applied in a less concentrated form, and so is not liable to cause discoloration or undue fibre shrinkage, while there is the additional advantage that the wool is, practically speaking, stationary, and thus there is no opportunity for the staples to become matted. In the mechanical system the wool is more automatically dealt with, and greater quantities may be more readily turned off. As a rule, the condition will be satisfactory; but there can be no doubt that it is quite easy to discolour wool by heat, and that this is done more

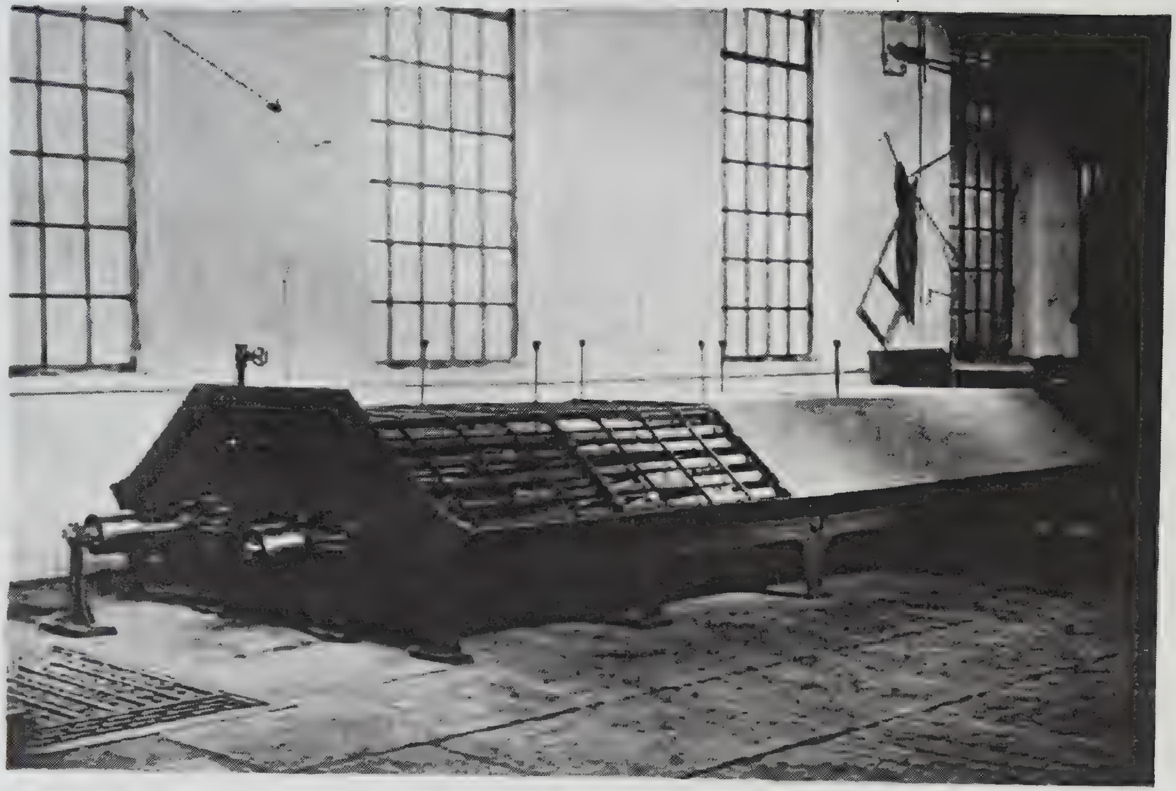


Fig. 69.—Table Dryer
(The left-hand portion shows wirework removed)

frequently than is ordinarily supposed. Thus the system to employ will depend upon particular circumstances. Often with certain classes of wool the deterioration by machine treatment is so slight as to be more than justified by the saving effected in time.

The Table Dryer.—In arrangement the table dryer is very simple, consisting of a wood or iron case with wirework as the top portion, which is shaped with flat top and sloping sides, or semicircular in form, as shown in Fig. 69. The wool is placed on the wire mesh, and to ensure uniform drying it must be uniformly spread. The hot air may be passed through the wool from the under side upwards, or may be passed from over the wool downwards, a fan either blowing the air through the wool or sucking it down through the wool. As a matter of fact, the best results are obtained by means of steam-heated pipes both over and under the wool, the air blast in this case usually being drawn down through the wool, while the under pipes by radiation maintain such a heat that the air is in the best condition for extracting the moisture from the material. Undue movement of the wool, which might result in felting, is by this means obviated. This type of machine is best placed in a chamber by itself. If the table is arranged with pipes below the wool only, the air must be forced upwards through the wool. This is liable to cause the wool to heave and to result in a certain amount of felting. In either case, but more particularly in the former, the turning over of the wool by hand is necessary to ensure complete drying.

Great care is necessary in arranging the air blasts, as it is by no means infrequent to find that the main blast gives rise to a vacuum, and that air is circulating through the wool in an inverse direction to that desired.

Mechanical Dryers.—The principle of the mechani-

cal dryer is precisely the same as that of the hand dryer, save that arrangements must be made for passing the material to be dried continuously through the machine under conditions which will ensure the thorough penetration of the mass by hot, dry air, with the least possible agitation, and consequent felting, of the material. A matter of primary importance, however, which is too frequently overlooked, is the getting away of the moisture-charged air and supplying its place with dry, moisture-abstracting air. In fact, it must be clearly understood that the whole principle of wool drying is dependent upon, firstly, raising the moisture-absorbing properties of air by raising its temperature; secondly, bringing this dry air suitably into contact with the wet wool fibre; and, thirdly, in carrying away this air immediately it becomes saturated with moisture, and consequently inefficient as a moisture abstractor. It must be clearly understood that, irrespective of this action, heat has practically nothing to do with the drying of wool.

There are many makes of drying machines, but most consist mainly of an oven into which the hot air can be suitably introduced and expelled; the steam-pipes, fan, etc., which control the hot air; and the traversing or carrying arrangements for the wool. As the wool in these machines is so fully subjected to the action of the air, it is of the utmost importance that the air temperature should be kept within reasonable limits, not exceeding, say, 110° F. In the case of steam heating, the temperature of the oven may be taken from the steam pressure; as a rule, however, for satisfactory results the pressure should not exceed 50 lb. per square inch. The fact must not be lost sight of, that heat may considerably modify even the chemical constitution of the wool fibre, and consequently its character and appear-

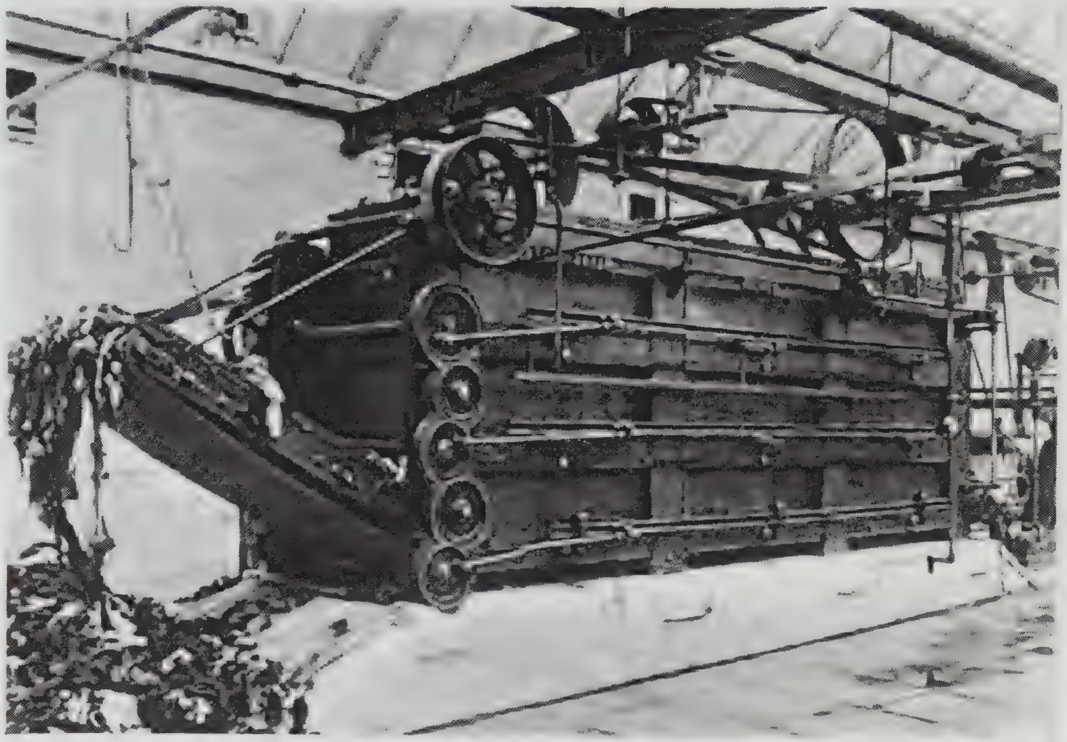


Fig. 70.—Petrie's Drying Machine

ance. Over-drying is a frequent cause of weakness in wool, as it removes the moisture essential to the constitution of the wool fibre, and further concentrates any alkali or other agent which may have been used during washing, and which may not have been removed, from the fibre. In addition, it has, no doubt, a certain action upon the natural fats, thus resulting in discoloration and further rendering the fibre liable to disintegration.

The type of drying machine made by Messrs. John Petrie, Junr., Limited, Messrs. Fielden and Sons, Messrs. Wm. Whiteley and Sons (of Huddersfield), Messrs. Summerscales (of Keighley), and others, is illustrated in Fig. 70, which in this case is made by Messrs. Petrie. Drying is accomplished in a rectangular oven, usually 21 feet long by 11 feet high. The hot air from a tubular heater (steam coil), generated by a strong fan, is passed through this oven, either along with the wool or in the reverse direction to the wool. As a rule, the fan and heater are placed underneath the oven, but if more convenient can be placed at the side. The wool is run from the feed sheet of the last scouring bowl into the hot air blast, which carries it up and deposits it on the uppermost of a series of three or five grid shelves, which by a peculiar action pass it through the machine. These shelves are arranged in tiers in the machine and are composed of bars or laths of which alternate ones are stationary, while the remainder may be actuated both laterally and vertically, their action being controlled by rods and fans conveniently placed outside the chamber. Thus the wool as deposited by the air blast on the fixed bars is raised by the movable bars, carried forward a few inches, and then as the movable bars fall below the fixed bars is retained by these fixed bars until the movable ones, having returned to their original posi-

tion again, rise through the fixed bars moving the wool still farther forward. By this means the end of the first shelf is reached, and as this shelf is shorter at its delivery end than the one beneath, the wool is dropped on to the shelf below, which works the wool in the reverse direction, eventually dropping it on to a third and lower shelf as just described. The same thing occurs with the fourth and fifth shelves, the last shelf delivering the wool on to a lattice, which conducts it out of the machine. The action of these shelves will be understood from Fig. 71.

The turn-off of this machine is very satisfactory, its capacity, when of the dimensions mentioned above, being 500 lb. per hour of material delivered in standard condition, namely, 16 per cent. of moisture.

All the firms mentioned build their machines on the above-mentioned general lines. There are certain differences, however, which are worthy of note. Messrs. Fielden employ perforated plates or trays as carriers for the wool, to which a sudden movement is given this throwing the wool forward. Messrs. Whiteley use hinged lattices of woven wire or planished steel for the same purpose, while Messrs. Summerscales form their lattices of laths and fixed chains, upon which coarse canvas netting is stretched. In this latter case the dryer is heated by steam pipes set at the top of the oven, air being drawn through the roof openings specially arranged for this purpose, by two powerful fans. In this way the air pressure controls the wool staples while on the lattices and prevents too much agitation.

A dryer built on a somewhat different principle is made by Taylor Wordsworth's Successors, and is finding extensive employment in drying the longest wools and hairs. It is known as Stone's Dryer (Fig. 72), and takes the form of a large round chamber which is subdivided

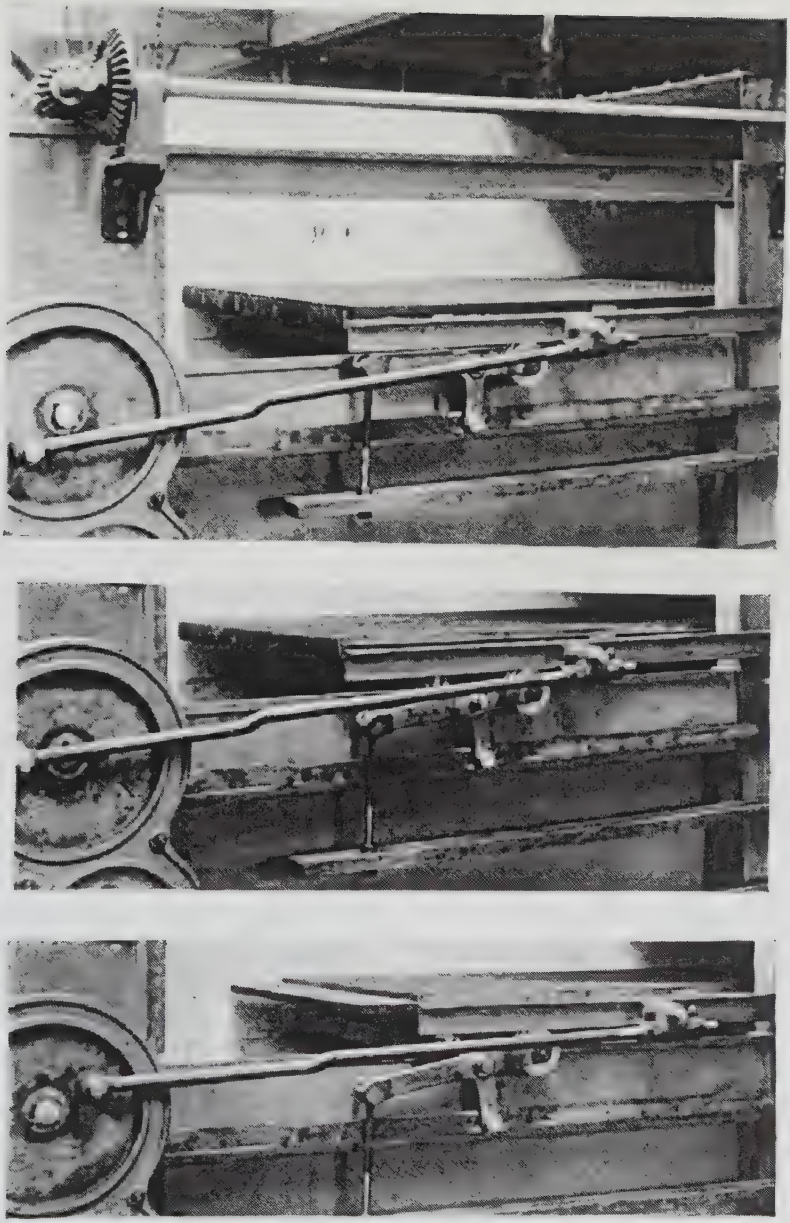


Fig. 71—Showing Action of Drying Machine Shelves

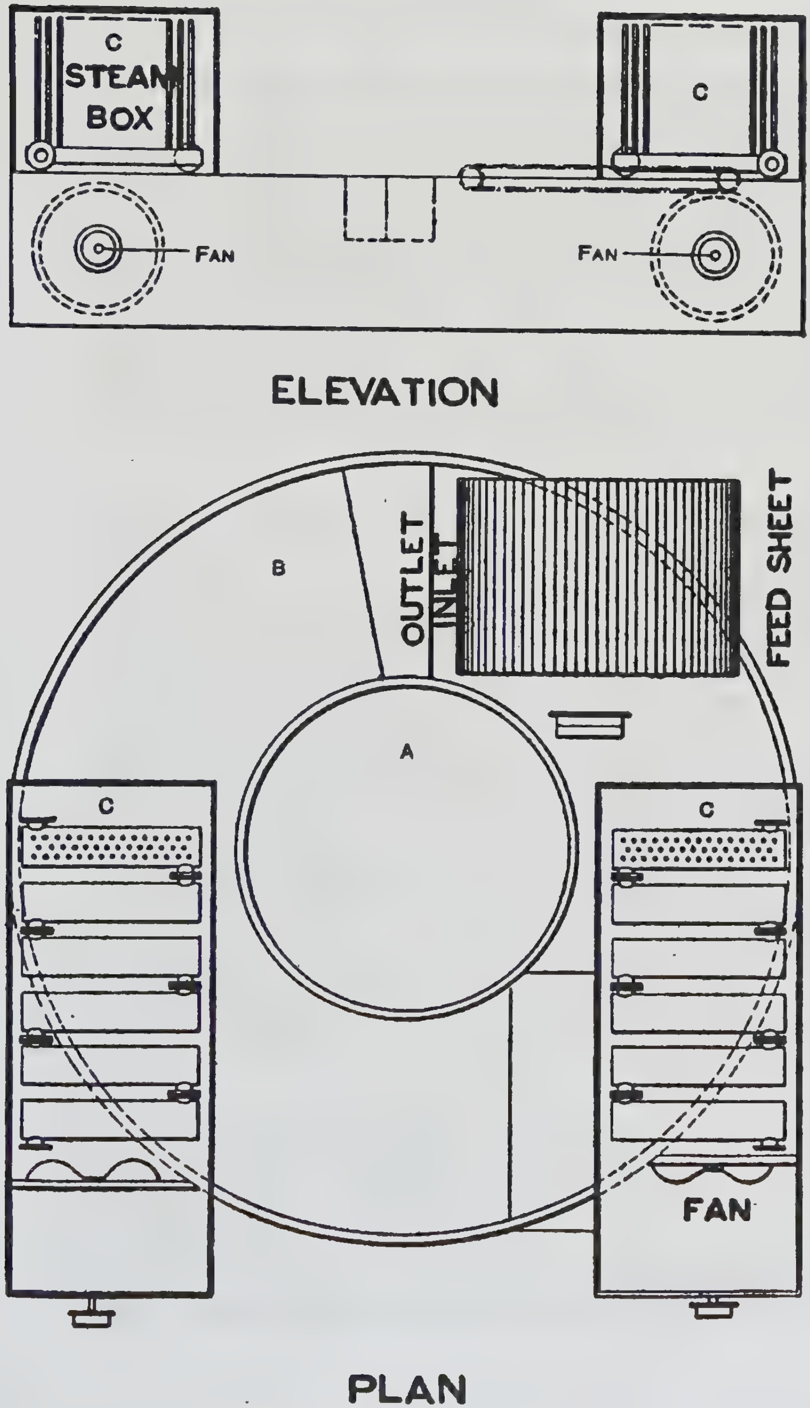


Fig. 72.—Stone's Wool Drying Machine

by perforated metal into three compartments, the inner one A containing two fans and the remaining two B a perforated revolving table, by which the wool is carried through the machine. Air generated by the fans is drawn through steam coils C; in turn it is directed under the perforated table and driven through the wool, and finally out of the machine. In this machine there is practically no agitation of the wool, yet the drying is thorough and fairly quick. If there is an objection to this machine, it is in its shape, this, in its relation to other machines, causing wastage of floor space.

The latest wool dryer placed on the market is that of Messrs. J. and W. McNaught and Co., of Rochdale. In this case the wool is, as it were, dried and carried forward by the hot air in conjunction with a series of revolving drums. The machine is divided into several compartments—five, seven, or nine—so that a low or high temperature may be employed as desired. Each compartment is, in a sense, independent of the other. Thus the wool is lifted by the hot air on to the roller of the first compartment; this hot air, now heavily laden with moisture, is passed directly out of the machine, fresh dry hot air taking its place. The roller in the first compartment now carries the wool forward to the next air blast, which blows the wool into the second compartment, arranged on similar lines to the first, and so on. It is usual to allow the air from the first two or three compartments to pass out of the machine, as it is heavily laden with moisture, while the air from the remaining compartments may successfully be used over and over again. There does not appear to be undue agitation of the wool staples, but so efficient is the drying that wool of certain classes may be passed through this machine in three minutes; thus

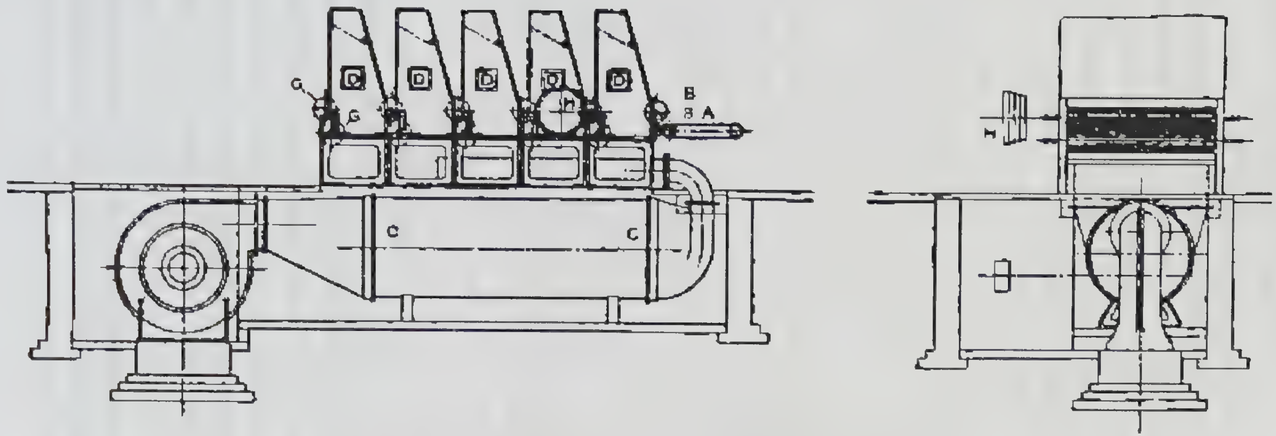


Fig. 73.—McNaught's Drying Machine

a machine 4 feet broad is said to be able to deliver 1,000 lb. of wool per day of ten hours.

In Fig. 73, A indicates the feed sheet which carries the wool to the feed rollers B. As it emerges from these rollers it receives a blast of hot air from the tubular heater C. This carries the wool upward about as high as the windows D, when it is allowed to fall

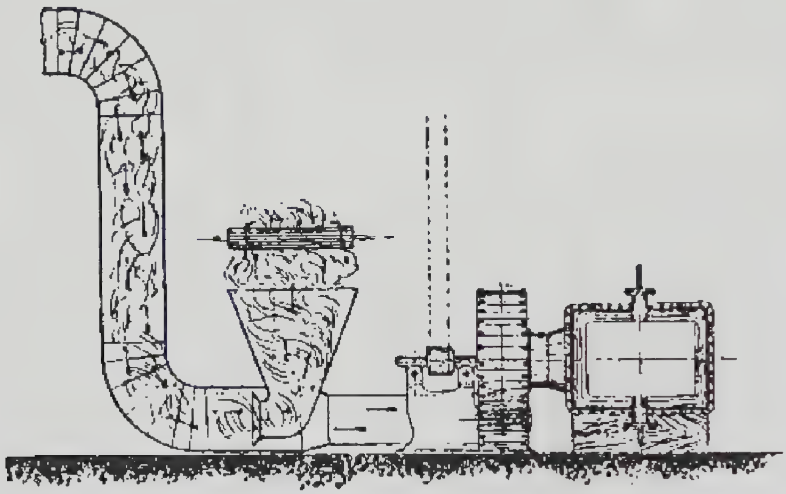


Fig. 74.—Conveyer Tube

on to an incline sloping down into the second pair of rollers, which pass the wool into the second chamber. The blast of air blowing through the wool takes with it through the perforated plate any short fibres and kemps that may be in the wool. This operation is repeated in the remaining chambers so that the wool is kept free and open until it is delivered by the last pair of rollers G. The windows D are constructed as doors so that at any time the operative can withdraw a handful of wool and examine it as to whether it has been sufficiently dried or not. The cone H is for

varying the speed of the machine to suit the various classes of material to be dried.

Transference Arrangements of Wool. — It is usually necessary to transfer wool from the dryer to the succeeding machine as directly and expeditiously as possible. For this purpose two forms of mechanical conveyers may be employed, namely, the revolving lattice and the conveyer tube. With either of these a certain amount of drying may be reckoned upon, as in the first case steam-pipes are placed under the lattice, while in the second a strong air blast, which may be hot, is employed. An example of the latter type is given in Fig. 74. It consists of a tube 10 to 14 inches in diameter, having at one end a hopper, into which the wool is deposited from the scouring or drying machine. The air generated by the fan (heated, if necessary) carries the wool forward, the delivery being arranged by means of a swivel tube into the hopper feed of one or more carders. If desirable, the wool may be delivered to the top of a large wire cage set over the carder feed, the idea being to open the staples by driving the wool up and allowing it to fall down in a flaky condition. Sometimes it is desirable simply to arrange the feed to deliver to a convenient position of the card-room, from whence it may be conveyed by hand to the card feeds.

Either the lattice or tube systems may be employed on the short wools, which do not require drying, but which should be conducted directly from the scouring bowl to the card. The tube system, however, appears to be the favourite, as it saves much labour. In the case of the longer wools an air-blast conveyer does not seem to be entirely satisfactory, as the whirling of the staples tends towards stringiness. As a rule, however, the saving effected by the conveyer justifies its use.

CHAPTER VIII

TYPES OF YARNS GENERALLY CONSIDERED

Each process, from the scouring of the wool to the finishing of the fabric, has some influence on the resultant piece; consequently each process will require careful adjustment, and possibly modification, for each style of wool, top or yarns under treatment. Nevertheless, certain broad principles may be laid down which, while not of the nature of "the law of the Medes and Persians, which altereth not," will serve a useful purpose in outlining the modifications possible and at the same time leave the manager free to adopt any variation he deems likely to produce the most satisfactory results.

The Difference between Long Fibre Spinning and Short Fibre Spinning.—Just as weaving or, more correctly, interlacing preceded spinning, so is it probable that long fibre spinning preceded short fibre spinning. Long fibres, such as flax and long wool, can readily be made by hand into thin slivers or rovings, as they would now be termed. Twisting converts these rovings into threads, fibre binding fibre, and the necessary strength is thus obtained. Very different from this is short fibre spinning (woollen spinning). The spin here is absolutely dependent upon twisting taking place at the same time that the elongation of a comparatively thick sliver into a sufficiently thin sliver

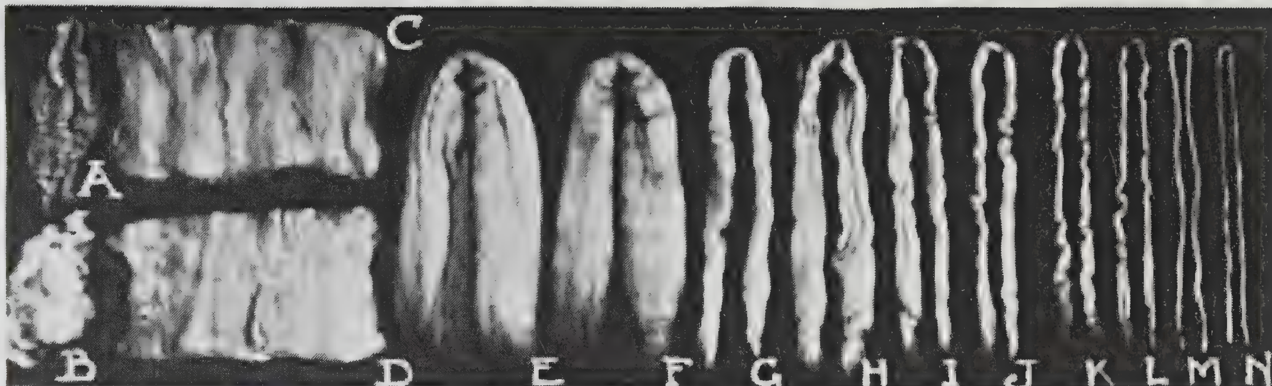


Fig. 75.—Worsted Lustre Long Wool Yarn Production; Range of Processes

A, Greasy Lustre Wool B, Scoured Wool C, First Preparer Sheets D, Second Preparer Sheets E, Third Preparer Sliver F, Last Preparer Sliver G, Combed Top H, Finished Top I, Slubbing from Two-Spindle Gill Box J, Slubbing from Four-Spindle Drawing Box K, Slubbing from Six-Spindle Weigh Box L, Reduced Slubbing in Six-Spindle Finisher M, Reduced Slubbing in Thirty-Spindle Rover N, Spun Yarn from Flyer Frame

for the thread required is effected, after which the necessary additional binding twist is inserted. This operation of drawing out or "spindle-drafting," as it is termed, which at the same time prevents the sliver from rupturing by inserting a drafting twist, is one that should actually be carried out by the would-be spinner by means of the finger and thumb, or, better still, upon the ordinary hand spinning wheel; what happens will then be thoroughly realised. Once thoroughly understood, the difference between these two methods and all the apparently complicated machinery of the modern mill falls into an ordinary easily-to-be-comprehended sequence working up to a well-conceived end.

The complete sequence of all wool spinning processes may be conveniently studied under three heads:

1. Bringing the material into a workable condition.
2. Preparing the material for the true spinning operation.
3. The true spinning operation.

As will already have been realised, the bringing of the material into a workable condition is effected on similar lines, whatever the wool may be, and whatever its ultimate destination. It must be thoroughly cleansed, dried, and freed from burrs and other vegetable impurities before it can satisfactorily be prepared.

It is in the preparing of the material that the first real differentiation takes place. To take typical examples. If the fibre is long—suitable for the typical Bradford worsted yarn—its length is made the basis of the treatment; thus every operation, while straightening out the more or less entangled mass of fibres, tends to lay the fibres parallel in the sliver; to a large extent, therefore, length of fibre and twist are made to

assist in the reduction of the comparatively thick slivers that come from the early preparing boxes to the thin roving which is placed upon the spinning frame, to be further elongated, and the necessary twist added to convert it into yarn. The operations usually employed are:

1. Preparing by means of a set of gill boxes.*
2. Combing and finishing.
3. Drawing.
4. Spinning.

As each of these operations is fully described in the section devoted to it, it is not advisable further to describe them here. From Fig. 75 the order of these processes can be well grasped, and a useful broad idea gained previous to studying the more or less bewildering processes and sub-processes involved in sets of combing and drawing machinery.

If the fibre is short—suitable for the typical woollen yarn—no attempt is made to obtain parallelism of fibre; in fact, the very opposite is aimed at. The fibres are jumbled together in any and every direction, forming a regularly mixed mass, from which a sliver is first formed by dividing up the broad film issuing from the carder into a number of smaller films, which may only be reduced finer and spun into yarn by means of spindle-draft. Thus the operations usually employed are:

1. Thorough mixing or blending by means of willow and fearnought.
2. Carding.
3. Condensing.
4. Roving or spinning on the mule.

* As preparatory processes for short or medium length wools, the worsted carding engine is substituted for gill boxes, as these latter cannot deal satisfactorily with fibre under, say, 7 inches.

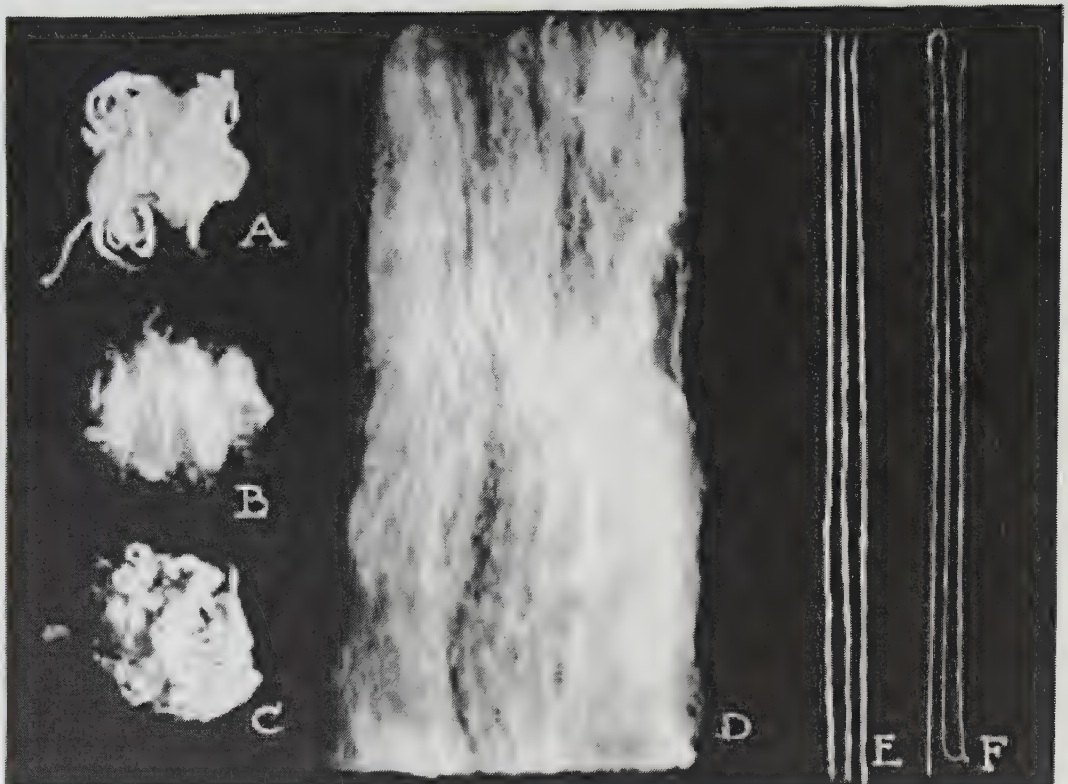


Fig. 76.—Woollen Yarn Productions: Range of Processes

A, Scoured Wool for Blending B, Willowed Waste for Blending C, Woollen Blend (oiled and willowed)
D, Scribbled Blend E, Condensed Sliver for Carder F, Mule Spun Yarn

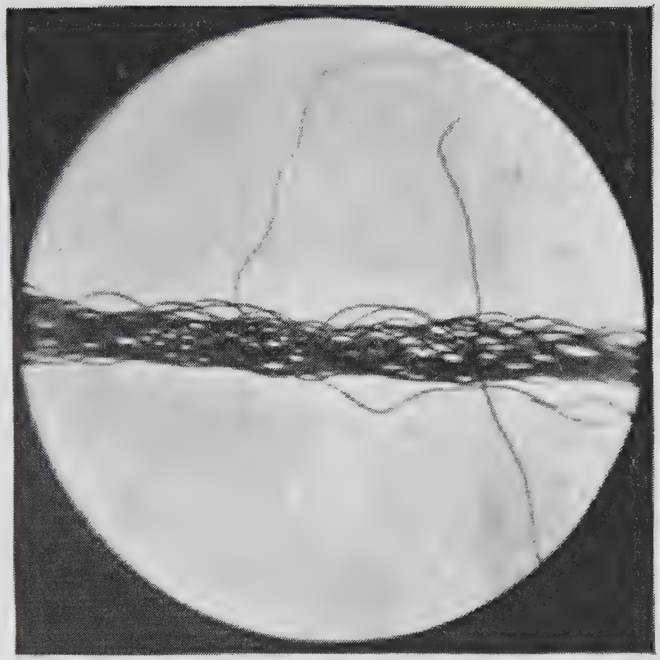


Fig. 77.—1/60's. Botany

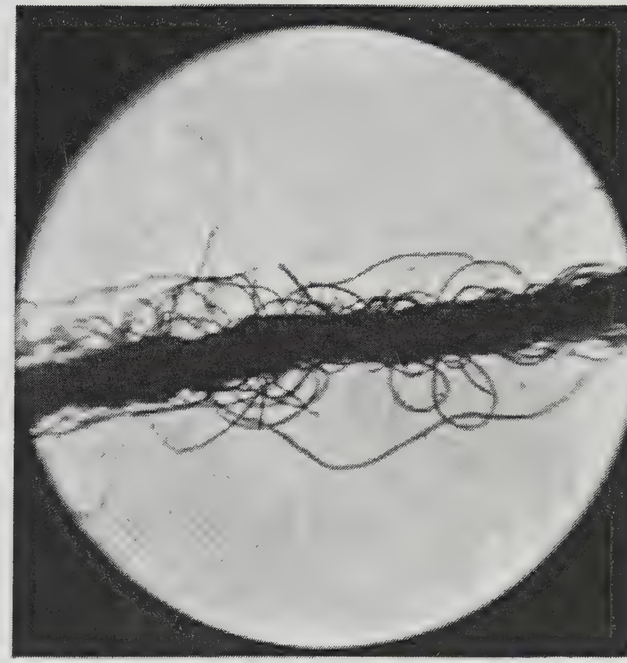


Fig. 78.—30's. Skeins Woollen

The count or thickness to which the carded sliver is condensed—affecting the extent to which it is drafted in the subsequent roving and spinning—will have a marked influence on the resultant yarn. From Fig. 76 the idea of the processes will be gained, and by comparison with Fig. 75 the very marked fundamental difference realised. Again, a reference to the photomicrographs shown in Figs. 77 and 78 will clearly show the difference between the worsted and woollen yarns. There are subtle arrangements of the fibres in the woollen thread introduced by the method of condensing, roving, and spinning which the woollen spinner will do well to realise and act upon.

Somewhat allied to both the foregoing methods is what is known as the French system of worsted spinning. In this case the preparation up to combing is somewhat similar to that obtaining in the worsted system. The drawing and spinning, however, are absolutely different, being simply based upon an open treatment of the fibre rather than upon the twist control so usefully employed in English drawing and spinning. Omitting twist necessitates support to the yarn in its passage through the various drawing boxes. This support is supplied by the porcupine coming between the front and back-drafting rollers, and, further, by the pith-like sliver being more or less consolidated by rubbing leathers coming between the front rollers and balling-head. As the French-produced sliver has neither marked parallelism of the fibres nor twist, it cannot be spun on any type of throstle frame, but must be spun on the mule. In Fig. 79 the action of processes employed in this system is clearly indicated. For short material the treatment here represented is doubtless the best yet available. The action of the fibre is of the

easiest; consequently there is that preservation of its length so essential to the spinning of a strong yarn in fine counts. Moreover, the characteristics of the raw material—softness, fulness, etc.—may be pronouncedly in evidence in the finished cloth. A near approach to this type of result is obtained on the Cone Drawing system (Fig. 80), the slivers being worked with less twist, and consequently much more openly, than upon the ordinary drawing system. Much hosiery and soft dress fabric yarn is produced upon both these systems.

It will be evident that between the extremes here described will come many means. Thus mohair, being taken as the typical English spun yarn (Fig. 81), and woollen as the typical mule spun yarn (Fig. 78), it will be evident that such examples as Cross-bred (Figs. 83 and 84), Botany (Figs. 85 and 86), and Hosiery yarn come in between these extremes. In fact, as remarked at the commencement of the chapter, the manager must use his judgment as to the extent to which he applies any of the principles here dealt with.

On pp. 193-5 will be found a fairly complete list of the various typical yarns of commerce and their uses, with the material employed in their production, the principle upon which they are spun, the range of counts, and the usual turns per inch.

Twist in Yarns.—If the method of preparation and spinning has a marked influence on the resultant yarn, it will be evident that the amount and direction of the final twist inserted will be equally potent. Twist has been said to be the spinner's enemy, yet at the same time his best friend; and certainly it may be of the utmost value to him in working materials; but, on

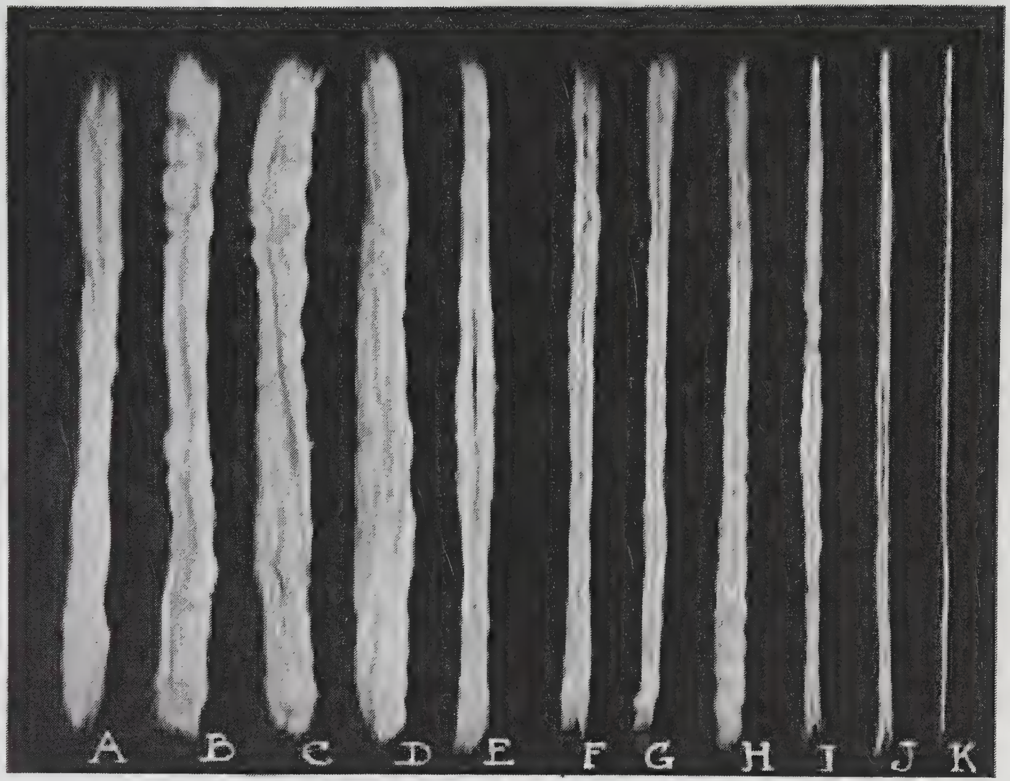


Fig. 79.—French (Dry-spun) Worsted Yarn Production: Range of Processes

A, Top from Eight-Bobbin Gill Box B, Slubbing from Eight-Bobbin Drawing Box C, Slubbing from Eight-Bobbin Drawing Box D, Slubbing from Twelve-Bobbin Drawing Box E, Slubbing from Twenty-four-Bobbin Reducer Box F, Slubbing from Twenty-four-Bobbin Slubbing Box G, Slubbing from Twenty-four-Bobbin Intermediate Box H, Slubbing from Twenty-four-Bobbin Intermediate Box I, Slubbing from Twenty-four-Bobbin Rover J, Roving from Forty-eight-Bobbin Rover K, Spun Yarn from Mule Frame

RANGES OF YARNS

N

Type of Yarn	*Materials Employed*	*Nature and Effect of Preparation and Spinning Processes*	*Limit of Counts*	*Turns per Inch*	*Uses*
SUPER BOTANY—white, single twist	Best Australian and Tasmanian greasy fleece wool, 64's to 90's qualities	Such as to produce smooth-faced and even yarn, with fibres of uniform length and arranged as parallel as possible. Chiefly "cone" drawn and "cap" or "ring" spun	60's-130's	60's = 12 130's = 20	As weft, occasionally as warp for Itaians, and various "all-wool" and cotton and silk warp cashmeres
FRENCH SINGLE—mule spun, white	Short "B.A." and "M.V." wools; also Australian blended to limited extent—58's to 64's qualities	Made from "dry-combed" tops, "French" drawn and mule spun, to give smooth but soft and full handling yarn.	56's	50's = 15	Soft handling dress fabrics
BOTANY COATING—white, solid shades and mixtures and marls, single and twofold	Australian fleece wool of good length and soundness and milling capacity—60's to 70's qualities. Short Australian, "B.A.," Cape wools and "skin" used for thicker counts. Discoloured wools used for dyeing into darker shades	Finest counts produced on "cone" drawing and "ring" or "cap" spun; thick counts "open" drawn and "cap" spun. Handle, soft and full—not very smooth. Mixtures obtained by gilling and drawing various coloured tops together. Marls produced by running together differently coloured rovings to give twist of pronounced colouring. Twists (coloured) formed from two colours of yarns	64's	1-40's = 9 2-40's = 10½	As warp and weft in worsted coatings, trouserings and suitings—slubbing dyed and piece dyed
FINE CROSS-BRED—white and coloured, single and twofold	Australian and New Zealand cross-bred (Down merino type) of nice length, softness, soundness, and uniformity—46's, 50's, and 56's quality. "Skin" and "Slipe" sparingly used	Fibres not straightened too much—yarn required soft and full handling. Spun on "cap" frames. Not very smooth in appearance	48's	1-38's = 15	As warp and weft in medium quality coatings and dress cloths — yarn and piece dyed
SERGE—white and coloured, single and twofold	Australian, New Zealand, and "B.A." medium cross-bred, of sharp and crisp handle and longish fibre; also certain home-grown wools of Down type. Qualities up to 50's	Made as full handling as possible. "Cap" spun. Not smooth in appearance, but bright	46's	1-20's = 7½	As above

RANGES OF YARNS—(*continued*)

Type of Yarn	*Materials Employed*	*Nature and Effect of Preparation and Spinning Processes*	*Limit of Counts*	*Turns per inch*	*Uses*
LowCross-bred,—white and coloured, twofold	Australian, New Zealand, and part "B.A." Lincoln-merino cross-bred, 32's to 40's qualities, of fair length and lustre	If lustre is important "flyer" spinning is employed: if price, "cap" spinning. "Ring" spinning occasionally used for good average yarn. Yarns are not smooth or soft, nor very even	36's	1-20's = 7½	As above, but in cheap goods
Single Lustre—super or ordinary, white	English long lustre wools and Colonial lustre and lustre merino crossbreds, 36's to 44's qualities	Chief aim to develop lustre smoothness and evenness. Best types "Nip" combed. "Flyer" spinning solely employed	40's	1-30's = 6	Lustre dress goods and linings—weft
Single Demi-Lustre—super and ordinary, white	Long-stapled wool, English or crossbred or both, not necessarily very lustrous. Qualities 32's to 40's. In low qualities (kemps present).	Yarn only fairly smooth and lustrous. Production at definite price is prime object. "Flyer" spun.	36's	1-36's = 5	As above
Mohair—super, medium and low, single and twofold	Turkey and Cape (American used for Home manufactures)	Aim is to arrange fibres as straightly and as parallel as possible to favour lustre and smoothness. Double and treble combing obtains on "Nip" and "Noble" combs, the latter for the lower qualities. "Flyer" spinning	48's	1-32's = 8 1-40's = 9½ 2-32's = 8½	Lustre dress fabrics—warp and weft
Alpaca—self-coloured and dyed, single	Peruvian (Arequipa) alpaca fleece	As mohair	40's	1-30's = 8 1-40's = 11	As above—used as weft
Camel's-hair—self-coloured	China, Egyptian, and Persian camel's-hair	Softness is the valuable characteristic. Thus yarn is soft-spun. Much is done to preserve smoothness in better qualities, which are "flyer" spun	40's		Dress fabrics and skirtings—weft
Cashmere—white, grey, and brown	Tibetan cashmere	Treatment in linen as finest botany wool yarns to produce maximum softness	60's		Dress fabrics—weft
Carpet Yarns—white and coloured, Two or more fold	Low Scotch, English, Colonial, and foreign wools, along with mohair and lustre wool noils. Vegetable fibres sometimes blended. Bright and strong qualities	Fullness very desirable. Yarns spun on worsted principle, but frequently not combed. "Flyer" spun, thick counts	24's		Weft in carpets

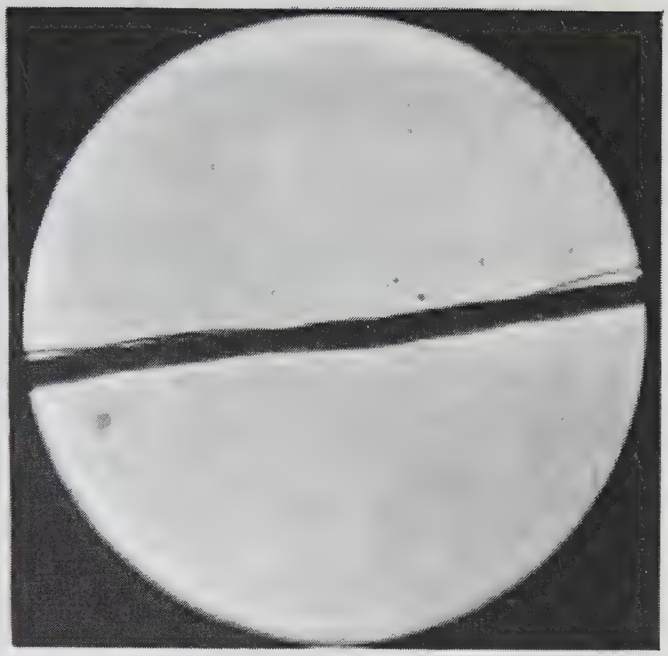


Fig. 81.—1/40's. Mohair

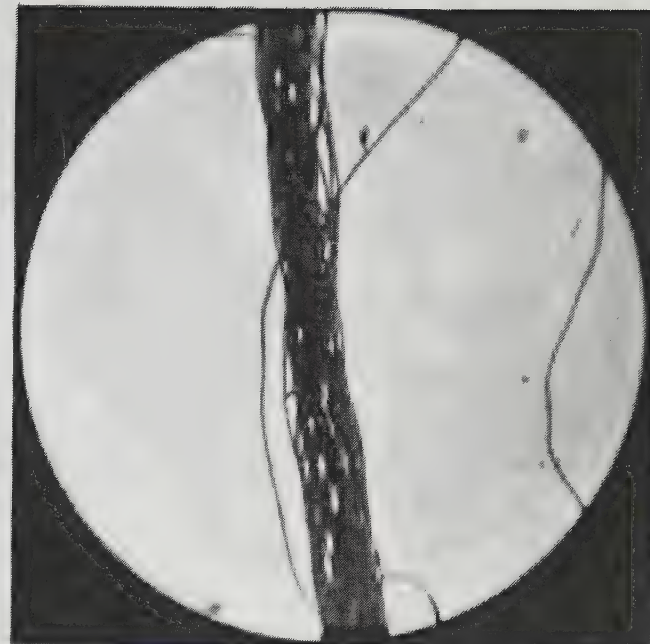


Fig. 82.—1/20's. English Lustre

Fig. 83.—1/40's. Cross-Bred

Fig. 84.—2/40's. Cross-Bred

RANGES OF YARNS—(*continued*)

Type of Yarn	*Materials Employed*	*Nature and Effect of Preparation and Spinning Processes*	*Limit of Counts*	*Turns per Inch*	*Uses*
HOSIERY—low, medium and fine, two or more fold; white, coloured, and coloured twists.	Low yarns: Colonial and "B.A." cross-bred; also low English fleece and "Slipe" wools—32's to 40's qualities Medium yarns: Colonial and "B.A." cross-bred fleece and "skin" wools; also medium English qualities Fine yarns: "B.A.," Australian, and Cape fleece and "skin" wools, as blended in qualities 50's to 58's	For low counts "open" drawing and "flyer" spinning; for medium counts "cone" and "flyer" spinning; for fine counts special "hosiery cone" and "flyer" spinning. Continental hosiery yarns, "French" drawn and "mule" spun. Twisting and folding on "cap" and "ring." Soft spun	32's	4·10's = 1¾ 4·16's = 3¼	Hosieries
MELANGE—single lustre	Lustre and cross-bred wool and mohair	Obtained from printed top by treatment as accorded wool and hair	40's		
GENAPPE—soft or hard twist—two or more fold	Medium and fine wool and mohair	Fibres arranged as straightly and solidly as possible in drawing and spinning. "Flyer" spun. "Gassed" to produce smoothness	40's		Fancy coatings, braids, healds, and cords
FANCY YARNS: Loop, Knop, Slub, Spiral Flake, and Spot	Various—wool, mohair and cotton	Twisting and folding together of yarns varying in material, count, and twist under conditions in which each yarn can be regularly or irregularly delivered			Fancy dress fabrics
WOOLLEN—Saxony in white, solid shades and mixtures, single. Two-fold for hosieries	Clothing wool (best classes)	Treatment the opposite of worsted. Fibres arranged transversely in yarn as well as laterally to give marked roughness and capacity for felting. Carding, condensing, and "mule" spinning employed	60 skeins (Yorkshire)	40sk = 17	Coatings and dress fabrics as warp and weft
WOOLLEN — medium and low	Wool and wool substitute (mungo, shoddy extract, and noil)	As above		8sk = 8	As weft in worsteds
WOOLLEN — Angola	Wool substitute and cotton	As above			Blankets, flannels and rugs

the other hand, it may totally spoil the finished product. The influence of twist is to solidify and harden yarn; it also renders it more durable. On the shade or colour it has a marked effect; for increased twist prevents penetration of the dye and results in a lighter shade. So much is this the case that in coloured cloths, in substituting single yarns for twofold, slightly darker colours need to be employed. If single yarns are being spun, the two factors are amount and direction of twist. The amount of twist inserted seems, on first consideration, a very simple thing, but brief consideration will show that it is not so. Twist may be stated as so many turns per inch, or as of a definite angle. Thus a yarn might be said to have 16 turns per inch, or its angle might be stated as running, say, at 30° with its length. The former is obviously the more practical, and certainly the more useful to the spinner, the production of whose frames largely depends upon the twist inserted; for spindle speed being fixed, and the twist varying roughly inversely to the thickness of the yarn spun, working backwards, fewer turns will mean thicker counts and consequently more weight through the machines; or working forwards thicker count means fewer turns, therefore a quicker delivery to the spindle by the roller, and consequently more weight turned off. From the designer's or cloth constructor's point of view twist might possibly be better stated as of a definite angle; for in the woven fabric weft has to cross warp, and the angles of twists in the two yarns may obviously affect the resultant texture. This aspect of the question, however, is still in its infancy.

Under the heading, "Amount of Twist," arises a very important matter, viz. that of relative twist. If, for example, a 1-25's Botany yarn yields a satisfactory result with sixteen turns per inch, what number of

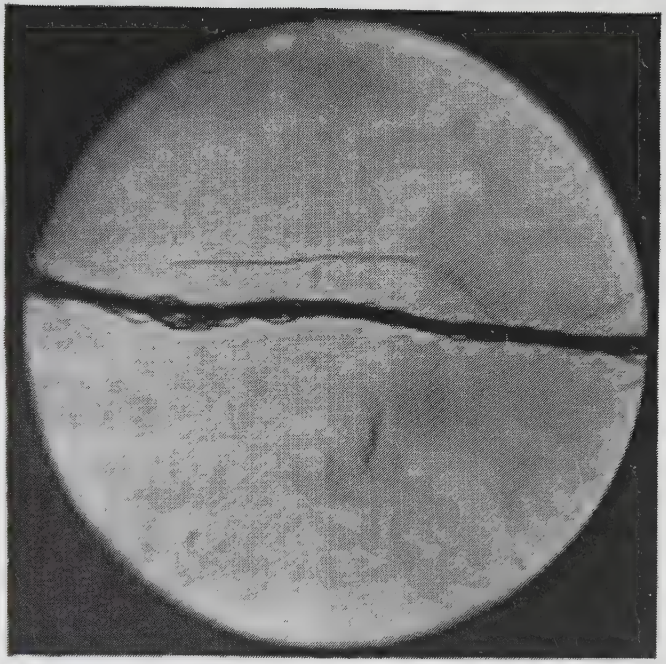


Fig. 85.—1/130's Botany

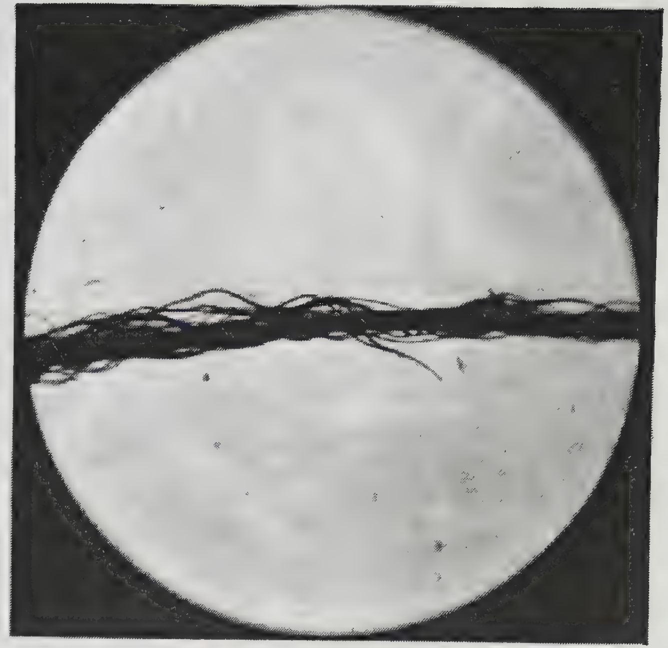


Fig. 86.—1/72's Botany

turns should a 1-36's have? On first thought, this might be taken as a simple proportion sum, thus:

As 25 : 36 :: 16 : x = 23 turns per inch for 1-36's.

Further consideration and a few rough pencil sketches will suggest, however, that twist should vary as the diameter of yarns. Thus as the square root of the yards per pound represents the diameter in the fraction of an inch:

$$\text{As } \sqrt{25 \times 560} : \sqrt{36 \times 560} :: 16 : x, \text{ or}$$
$$\text{As } \sqrt{25} : \sqrt{36} :: 16 : x, \text{ or}$$
$$\text{As } \sqrt{5} : \sqrt{6} :: 16 : x =$$
19 turns per inch for 1-36's Botany

As shown in Fig. 86A, however, this only means that nineteen turns per inch will maintain the same angle of twist *on the surface of the 1-36's as on the surface of the 1-25's*, the truth being that the interior relationships of fibre to fibre are actually better maintained by the direct proportion method given than by this latter method. In actual practice the spinner and designer should fully realise what this means, and add their practical experience and insight to these theoretical considerations in finally deciding the twist to adopt.

The influence of the amount of twist on the contraction of the yarn in subsequent operations is also worthy of special consideration. Some exceedingly fine examples of crepon cloth are produced by contrasting in the fabric soft and hard twisted yarns; in one case a small fibre shrinkage only results, while in the other a fibre and a structural shrinkage results, producing the marked crimping of the non-shrinking material noted in these goods.

Again, it is probable that each type of yarn is strongest and most useful with a certain definite twist

in proportion to the count. This definite twist should be ascertained by careful experiment.

The effect of direction of twist in yarns woven alongside one another in the same fabric is remarkable. On the same material, spun in the same way, woven in the same way, dyed and finished in the same way, the result is so different that it is made the basis of whole ranges of "shadow" patterns.

If, then, the amount and direction of twist be taken together, and especially if applied to coloured yarns, the possible variety of effect is remarkable. This will be further realised by reference to Fig. 86B, in which the possibilities of varying the twisting of a twofold yarn are graphically illustrated.

It is thus very evident that in this and in many other cases the spinner and designer should work together if the best results are to be obtained.

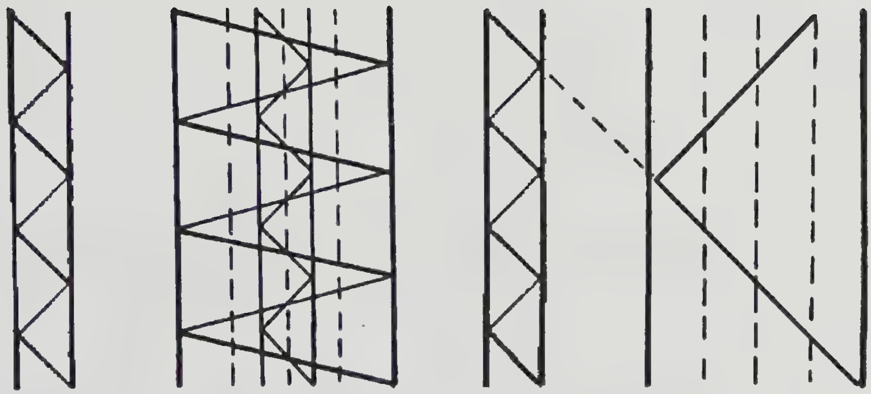


Fig. 86A

Maintaining the same number of turns per inch

Maintaining the same angle of twist

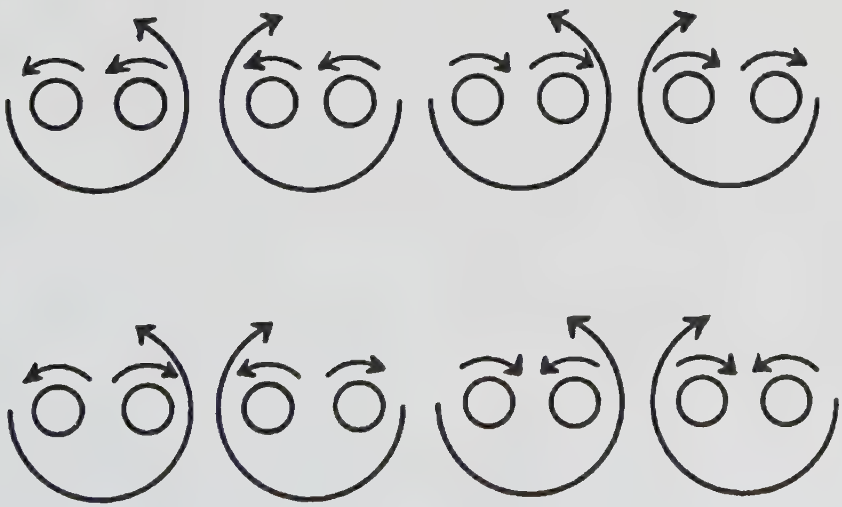


Fig. 86B

Illustrating the various conditions of twisting a simple two-fold yarn

CHAPTER IX

THE PREPARATION OF LONG WOOLS (ENGLISH), CROSS-BRED WOOLS, AND MERINO WOOL FOR COMBING

The preparation of the various wools for any of the several systems of worsted spinning will often be a compromise; for, on the one hand, the nature of the raw material may necessitate certain treatment, and on the other hand, it is quite possible that the ultimate combing or spinning processes may equally necessitate some other treatment. It is rarely that the two requisites are identical; but, even when they are not so, sound judgment may effect a compromise that at least fairly well fulfils both requirements and yields the desired result. It is thus evident that the comber must bear in mind the nature of the raw materials dealt with, and further the ultimate requirements from the top he produces. Again, it must not be forgotten that hard leather and rigid iron are not comparable to the deft fingers and actions of the spinner; there may be limitations in the preparing, combing, and spinning machinery itself. It is possible, however, that the latter difficulty is more than counterbalanced by the regularity of movement and control exercised by steam or electrically driven machinery, for it is well to remember that the great cotton industry of this country is actually a machine created industry.

There are two characteristic methods of preparing wool for the operation of combing, these being based on the extremes of long and short wools. These two extreme methods are modified for wools of an intermediate length as experience suggests. The basis of the preparation of long wools is a straightening out process, effected by means of five or six gill boxes, usually termed "preparing boxes" to differentiate them from the gill boxes employed in the processes of "Finishing" and Worsted Drawing subsequent to combing. The basis of the preparation of short wools is a mixing up and thorough reversing of roots and tips of the wool staples, effected by means of the worsted carder—a machine designed on similar lines to the woollen carder, but so employed that if parallelism of the fibres is not actually the result of the carding, at least the wool is left in such a state that this parallelism may readily be developed in the processes immediately following. As a dividing line for these "long" and "short" wools 7 to 8 inches may be given. With these lots, which may be either prepared or carded, the ultimate purpose to be fulfilled by the material, or its cost, usually decides the process used. Thus a lustre top can be best made from "prepared" wool, and a full and soft-handling top from the "carded." The carder, however, gives a more thorough treatment of the fibres, and consequently a better "tear" (proportion of top) than the preparer, but such treatment costs more, owing to the relatively small output and high cost of the machinery required.

The Preparing Gill Box.—The preparing gill box simply consists of a suitable feeding apparatus—usually a feed sheet, back rollers, fallers or gills, front rollers, and a delivery apparatus; in the first boxes of a set,

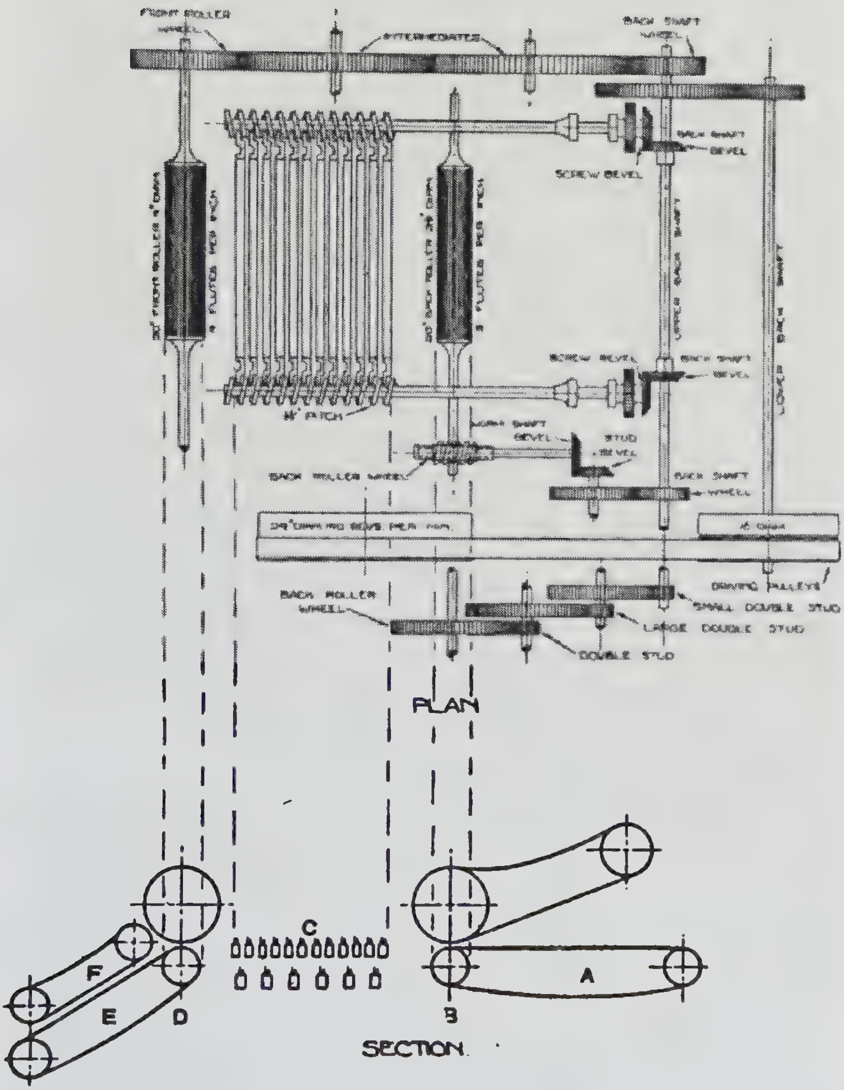


Fig. 87.—Plan and Section of "Sheeter" Preparing Box

usually a "sheeting" apparatus, and in the subsequent boxes a "can" delivery apparatus. The construction of such a box will readily be understood from Fig. 87. Its action is very simple. The wool, "made-up," is fed on to the feed sheet A in a longitudinal manner, and passes between the slowly-revolving back-rollers B. On emergence from these the gills C—worked in two pairs of screws and lifted and depressed by cams or tappets formed on these screws—rise up and pierce it, and, moving forward quicker than the rollers deliver the wool, draft it out and straighten it. The gills in turn deliver the wool to the front rollers D, which again, drawing the wool more quickly than the gills deliver it, further elongate and straighten the fibres. From the front rollers of the first two boxes of a set of say six the wool falls on to an endless leather sheet E, which in turn delivers it to a continuous leather apron F, which wraps the wool film by film upon itself until a "sheet" of wool of sufficient thickness is produced, when the attendant breaks it across and feeds it into the subsequent box. If the box is a "can" box the sliver passes through a funnel and press rollers into a cylindrical can, from which the sliver may be redrawn in a straight, unentangled condition.

Certain details of the preparing box require more than passing comment, and of these the faller action claims first notice. The fallers rest on bars or "saddles," as they are termed, set on each side of the machine, and they are traversed by screws or threaded shafts, two of which—an upper and a lower—are provided, again on each side of the box. To keep the fallers upright in position, the end of each is twisted to an extent which allows for the incline of the screw in which it fits. The drive is from the upper back shaft, through bevel wheels to the lower screws, and

from these to the upper pair, though in this case revolution is in the reverse direction. Thus in the top screws the faller movement is outward, for drafting purposes, but in the bottom set a return action is given. Only half the number of fallers need be worked in the bottom screws, as the pitch of the latter is as coarse again as that of the upper set, giving as a consequence a faller movement twice as fast. The lifting of the fallers at one end of the traverse and the depressing of these at the other end are effected by cams set at the end of the screws; upright conductor bars and the saddle ends also serve to control the fallers and keep them in an upright position so as to ensure engagement in the thread of the screw into which they are being driven. Perfect timing is, of course, essential to avoid locking; and as similar trouble may result from excessive vibration the speed at which the fallers are dropped must be kept within reasonable limits.

Fallers.—An idea of the form of the faller will be gathered from the plan, as in Fig. 88. Full details of the types necessary for the various boxes will be supplied hereafter. Generally the pins are driven quite through the bar, and in all save the first box, where a single row is occasionally employed, the pins are arranged in double rows with pins in one row opposite the spaces in another to ensure more thorough combing. The piercing of the layer of wool when the faller is lifted is rendered more gradual through the back row of pins being $\frac{1}{8}$ in. longer than the front; but in the case of the first box, where the wool is ofttimes matted, a dabbing brush to press the fibre down is necessary also. As so much depends on the action of the pins, every care should be taken to keep them clean and in good repair. Few things have greater

wearing influence than wool. In a surprisingly short time, with certain classes of fibre the ends of the pins may be bent or they may become slit, causing lumps and slubs wherever they are in contact with the wool. The pins frequently break, and if not replaced the wool goes forward to the comb with certain unopened fibres, and as a consequence produces an abnormal amount of noil.

Rollers.—In long wool in particular the nature of the fibre is such that it is easily ground into pieces if strained under the heavily weighted and coarsely fluted metal rollers which are necessary to obviate slipping of the material during the drafting process. To minimise this difficulty it is usual to run endless leathers round the rollers, in the first and second machines the top back rollers taking the leather, and in the can boxes, where shorter drafts are given, the bottom front roller only. In the two sheeter boxes the leathers serve a double purpose: in addition to providing a bed for the fibre in the roller nip, the back roller leather helps to converge the staples coming to the rollers from the ordinary feed sheet, while the front leather serves as support for the lap formed on the sheet above it. It need hardly be stated that a condition vital to good work is that the leathers be in good repair. Should they be "holed" or badly sewn, or should they sag when running, an uneven and wasty lap or sliver is unavoidable.

Weighting of Rollers.—The degree and uniformity of pressure applied to gill-box rollers is a matter of no small moment. In the older forms of machine weight is added at each side of the box by an independent wheel; this lowers a bush, which in turn compresses

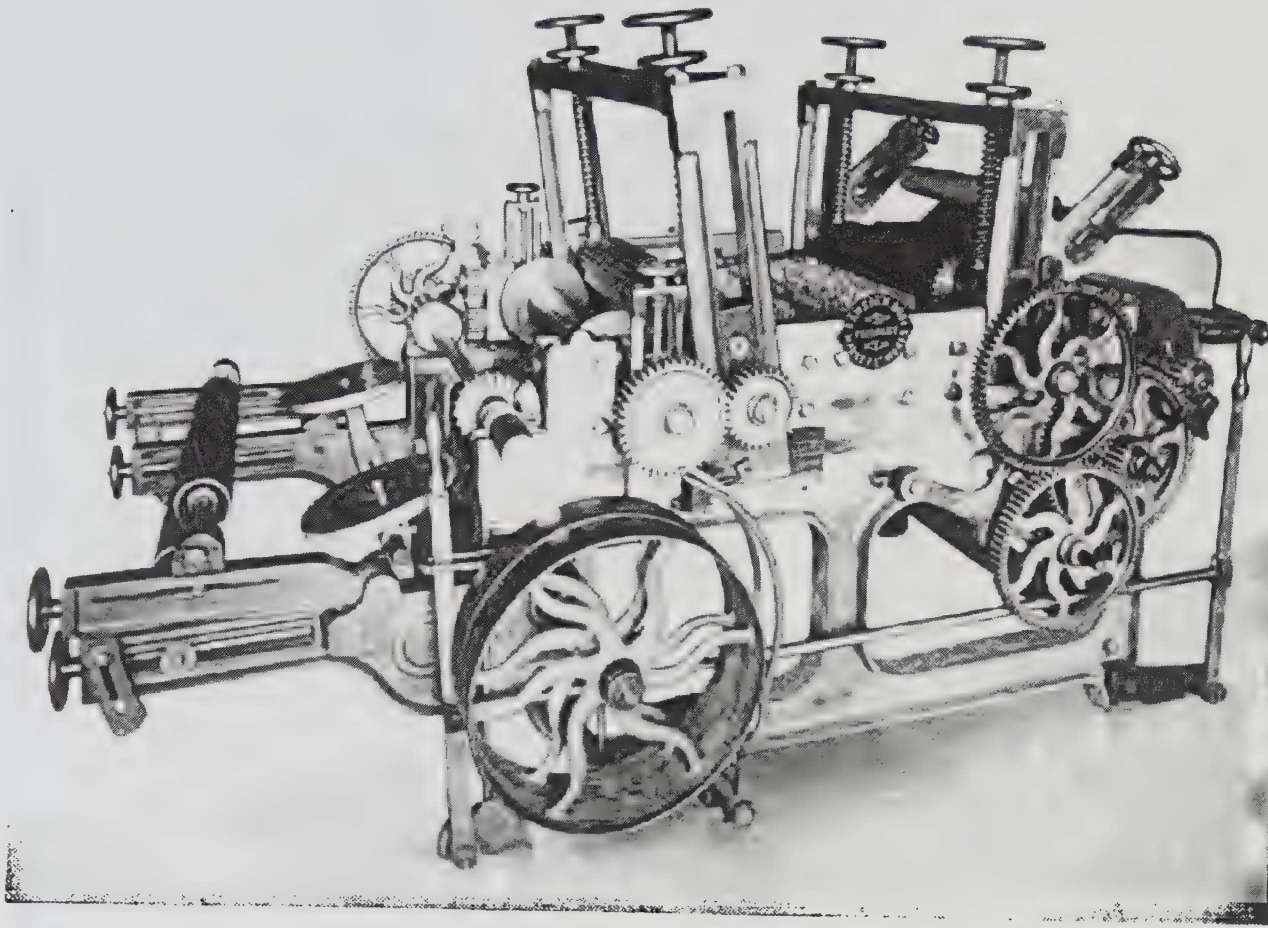


Fig. 88.—Preparer with Double Screws

a spring resting upon the top roller bearing. Seldom is the weight applied with absolute uniformity; there is too much weight at one side or too little, with either breakage of fibres or more or less slippage. The defect has been remedied, however, in recent machines. Whitehead and Layland's patent provides for an arm horizontally hinged in the centre of the framework with its ends of the hand wheels, which work as before described. In this case the bushes are free to move vertically, so that even though weight be added at one side only through the agency of the centred arm, it is adjusted to both ends of the rollers.

Making up or Feeding.—The action of a preparing box does not need much study to show that if the length of the fibre is to be preserved the material should be presented to the rollers, and by these to the fallers, in as straight a condition as possible. Too frequently feeding is neglected, especially at the first box, when the material is more or less detached, with the result that the fibres enter the nip in a crosswise direction and, both ends being held at the same time, they are broken rather than drafted by the action of the fallers. The exercise of care here will be amply justified in the superior top ultimately produced, and in the quantity of this as available from a given quantity of wool. In the second and third boxes lap feeding is employed, while slivers are formed for the later machines, and to avoid draft being applied twice in the same direction —a procedure which spoils the uniformity of the end —the end of the lap or sheet opposite to that delivered by the preceding box should be run first into the machine to be fed.

Weighing and Equalising of Slivers.—To favour

regularity of end, both as regards its weight and thickness, it is necessary in preparing to employ knock-off motions from the third box onwards, which stop the machine on a determined length being delivered, and thus provide opportunity for the slivers to be weighed and their condition, whether heavy or light, to be judged. As a description of the motions employed is more conveniently given in connection with the processes of spinning, readers are referred to the volume dealing with this subject. On the weights being found, cans containing light slivers and heavy ones are put together behind succeeding boxes and the ends are then "doubled" to equalise each other. Much variation obtains as to the number of ends to combine, but for long lustre wools and hairs 12 to 14 doublings at the fourth, 12 at the fifth, and 14 at the last are considered suitable.

Addition of Oil in Preparing.—When treating certain lots, the addition of oil becomes necessary during the preparing process. This is especially the case if the operation of back-washing is to be omitted, as no further opportunity is given whereby the fibres may be oiled for the combing and spinning processes in which their control becomes a necessity. Generally about three per cent. is added, usually at the fourth box, so that in succeeding machines a perfect distribution may be effected. Special motions are employed for these purposes; these will be described in the section dealing with Back-washing.

Particulars of a typical set of preparing boxes capable of turning off about 1,250 lb. of wool per day of ten hours will be found tabulated on p. 207.

For this set—which is full-size—six boxes are taken, but very often five are used, the sixth being

DETAILS OF PREPARING SET (ORDINARY BOXES)

Suitable for Longest Lustre Wools and Hairs

		Sheeter Boxes		*Can Boxes*			
		1st	*2nd*	*3rd*	*4th*	*5th*	*6th*
Rollers	Diam. of Top Back Roller (inches)	6	6	6	5	4½	4½
	Diam. of Bottom Back Roller (inches)	3½	3½	3½	3	3	3
	Diam. of Top Front Roller (inches)	6	6	6	5	5	5
	Diam. of Bottom Front Roller (inches)	4	4	4	3½	3	3
	Flutes—Back Rollers (per inch of diam.)	4	4	4	5	5	5
	Flutes—Front Rollers (per inch of diam.)	3	3	4	4	5	5
Fallers	Pitch of Screw* (inches) . .	1½	1¼	1	⅞	⅞	¾
	Fallers in Top Screws . .	12	12	14	14	16	16
	Fallers in Bottom Screws . .	6	6	7	7	8	8
	Fallers rising per minute . .	120	130	140	150	160	180
	Thickness of Pins (wire gauge)	7's	8's	9's	11's	12's	13's
	Length of Pins† (inches) . .	3	3	2⅞	2¾	2⅝	2½
	Pins per inch . . .	2½	3½	4½	5½	6½	7
	Set-over‡ (in inches) . .	22	22	20	18	16	16
Drafts and Ratches	Back Draft§	7½	5	4	3	2	1½
	Front Draft‖	6	6½	6½	7	7	7
	Total Draft**	45	32½	26	21	14	10
	Back Ratch†† (in inches) .	3	3½	4	4½	5	5½
	Front Ratch‡‡ (in inches) .	2½	3	3½	4	4½	5
	Total Ratch§§ (in inches). .						

* Pitch of screw gives distance traversed by fallers for one revolution of screw.
† Particulars of length given are for longest rows of pins. Shorter rows vary ⅛ to ¼ inch.
‡ Set-over gives distance over which faller is pinned.
§ Back draft: Draft between back rollers and fallers.
‖ Front draft: Draft between fallers and front rollers.
** Total draft: Draft between back and front rollers.
†† Back ratch: Distance between nip of back rollers and fallers.
‡‡ Front ratch: Distance between fallers and nip of front rollers.
§§ Total ratch: Distance between nip of back rollers and nip of front rollers.

reckoned as that at the back-wash gilling process. In other cases so few as four machines are employed, but

the treatment given to the wool by each machine in such a small set is such as to considerably injure it for combing purposes and for spinning, and consequently cannot be truly considered economical.

The foregoing list requires certain explanations. In the first place, a word regarding the use of the particulars it contains is necessary. Though every endeavour has been made to render such data as reliable as possible, the supplying of this may become a positive danger if a wrong idea be held regarding its utility. It should not be forgotten that different lots of wool, even when they are of the same class, often vary very widely, and that therefore no information more than that generally applicable can be given. Particulars of this character may, however, prove very serviceable in practice if the principles on which they are based be understood, if they are used as guidance, and modified for the various wools, according as reason and commonsense suggest.

It will be observed that the particulars and treatment here indicated are for the longest preparing wools and hairs. For the shorter classes of these materials more control of the fibre is necessary, and therefore the rollers of the various machines would be smaller, the fallers would be more numerous and closely arranged, and the pins would be shorter. The drafts and ratches would also need to be lessened.

Much variation of opinion obtains among practical men as to how these last-mentioned features should vary. It does seem desirable to give, first, a thorough opening of the staples through the agency of long total drafts in the first boxes, and afterwards attend to straightening by employing lesser drafts. Good straightening may be considerably favoured by a judicious arrangement of the individual drafts. At the beginning

the back draft is necessarily high for opening purposes, but later this should be markedly decreased at each box, as this treatment is somewhat violent. On the other hand, the front draft should be gradually increased from the first box onwards, for the drawing of the wool through the fallers by the front rollers (front draft) is done more easily and better than by forcing the fallers through the wool as held by the back rollers (back draft).

Much depends upon the ratches of a box for successful treatment of the fibre. They must not be too long, or the fibres will "ride" the fallers; neither must they be too short, or the fibres will be broken. It is here that a careful study of the condition of the material proves useful. Should the lot be loose in staple and shortish, lesser ratches are necessary than if the fibre is good in cohering capacity through being in condition, of uniform length, and of well defined staple. Generally speaking, at the first box in the set the back and front ratches should be short; after this, when certain opening has been done and the fibres have frictional contact on each other, gradual lengthening of both ratches may be done without fear of injury.

Draft Calculations.—From the foregoing description it will be gathered that "draft" in preparing gill boxes depends on the difference in drafting capacity of (1) the fallers in relation to the back rollers, (2) the front rollers in relation to the fallers, and (3) the front rollers in relation to the back rollers. The first variation is the "back draft," the second the "front draft," and the third the "total draft," this latter being a multiple of the remaining two. For calculating purposes it is necessary to consider all the factors which influence the front and back rollers and fallers—wheels, rollers and

screws—from the standpoint of whether, when dealt with in the same way, they increase or decrease their drafting capacity. If, then, all "increases" be multiplied together, and divided by the multiple of all "decreasers," the answer will be a draft sufficiently near the actual draft obtaining, for all practical purposes. Instead of the terms "increasers" and "decreasers," a division into "drivers" and "drivens" is frequently made in practice, the following rule being applied :—

Drivers : Those wheels, rollers, etc., which, when *increased* in size or speed, give *more* draft.

Drivens : Those wheels, rollers, etc., which, when increased in size or speed, give less draft.*

The larger result divided by the smaller gives the draft required.

Reason for this may readily be seen on reference to the plan of the box, as in Fig. 87. It will be observed that the back rollers, front rollers, and fallers (the drafting parts) are all driven from one point—the "upper back shaft" as it is termed. Suppose, now, the "draft wheel" (33) be increased. It would drive the front roller quicker, and the effect of this would be to increase the drafting capacity. It would therefore be a "driver." On the other hand, the "front roller wheel" (50), when increased, would reduce the drafting capacity, as it would cause the front roller to revolve more slowly. This would be a "driven." All parts should be studied in this way, but it should be specially noticed that it is draft only which decides the classification ; it is not speed ; for in the case of the back roller, *more* speed gives *less* draft, as the following illus-

* The fact that a wheel as when geared into another may be said to be *driven* by it or to be *driving*, has no bearing whatever upon this calculation. It is a matter of effect of size or speed of wheels upon draft.

tration shows, and therefore all increasers or drivers for draft are decreasers or drivens in a speed calculation. Intermediate wheels also—single stud wheels, not mounted on shafts or rollers—are not taken account of in these calculations, as these just transmit the power supplied to them without influencing the draft in any way.

	Back Roller		*Front Roller*		*Total Draft*
	(Equal diameters)				
(1)	10 revs.	..	70 revs.	equals	7
(2)	20 ,,	..	70 ,,	,,	$3\frac{1}{2}$
(3)	10 ,,	..	90 ,,	,,	9

Therefore to increase the front roller speed gives more draft, and to increase the back roller speed less draft. In the case of the fallers, to increase their speed gives more draft in a " back draft " calculation and less draft in a " front draft " calculation.

Below is given a complete classification of the parts in a box geared as shown in Fig. 87 on p. 201 :—

(*a*) Front Draft (front rollers on fallers):

Draft wheel (33)	as increased	gives	more draft ;	therefore		Driver
Front roller wheel (50)	,,	,,	less	,,	,,	Driven
Front roller (4" diam.)	,,	,,	more	,,	,,	*Driver
Back shaft bevel (20)	,,	,,	less	,,	,,	Driven
Screw Bevel (18)	,,	,,	more	,,	,,	Driver
Pitch of Screw ($1\frac{1}{4}$")	,,	,,	less	,,	,,	Driven

Calculation stands:

$$\frac{\text{Drivers}}{\text{Drivens}} \quad \frac{33 \times 4'' \times 3.14^{*} \times 18}{50 \times 20 \times 1\frac{1}{4}''} = 5.94$$

* Seeing that it is capacity which governs draft, the circumference and not the diameter of rollers must be taken in calculations to find the front and back drafts. In the total draft calculation conversion from diameters is not necessary, as both rollers are included in the calculation, and if changed they would still retain the same relationship to each other.

(*b*) BACK DRAFT (fallers on front rollers):

Shaft bevel (20)	as increased gives	more draft;	therefore	Driver
Screw bevel (18)	" "	less	" "	Driven
Pitch of Screw ($1\frac{1}{4}''$)	" "	more	" "	Driver
Back shaft wheel (22)	" "	less	" "	Driven
Large double stud (40)	" "	more	" "	Driver
Small stud bevel (18)	" "	less	" "	Driven
Worm shaft bevel (20)	" "	more	" "	Driver
Worm (1)	" "	† less	" "	Driven
Back roller wheel (30)	" "	more	" "	Driver
Back roller ($3\frac{1}{2}''$ diam.)	" "	less	" "	*Driven

† Say to double worm.

Calculation stands:

$$\frac{\text{Drivers}\quad 20 \times 1\frac{1}{4}'' \times 40 \times 20 \times 30}{\text{Drivens}\quad 18 \times 22 \times 18 \times 1 \times 3\frac{1}{2} \times 3.14} = 7.65$$

(*c*) TOTAL DRAFT (front rollers on back rollers):

Draft wheel (33)	as increased gives	more draft;	therefore	Driver
Front roller wheel (50)	" "	less	" "	Driven
Front roller ($4''$ diam.)	" "	more	" "	Driver
Back shaft wheel (22)	" "	less	" "	Driven
Large double stud (40)	" "	more	" "	Driver
Small stud bevel (18)	" "	less	" "	Driven
Worm shaft bevel (20)	" "	more	" "	Driver
Worm (1)	" "	less	" "	Driven
Back roller wheel (30)	" "	more	" "	Driver
Back roller ($3\frac{1}{2}''$ diam.)	" "	less	" "	Driven

Calculation stands:

$$\frac{\text{Drivers}\quad 33 \times 4'' \times 40 \times 20 \times 30}{\text{Drivens}\quad 50 \times 22 \times 18 \times 1 \times 3\frac{1}{2}''} = 45.7$$

The "total draft" is of course made up of back and "front drafts." Multiplication of these drafts, and not addition, is, however, essential for correct results, for it must be remembered that one yard drafted, say, into seven at the back of the box, is re-drafted, each yard seven times more, at the front of the box. Then—

"Back draft" × "Front draft" = "Total draft,"

or

$$7.65 \times 5.94 = 45.4$$

The discrepancy 0.2 is brought about by the ignoring of small fractions. Such a result is sufficiently near for practical purposes.

In the latter boxes of the set the worm and pinion gearing to the back roller is discarded, and the ordinary double-stud drive is used instead. This is because big drafts, necessitating the very slow movement of the back roller, are no longer required. The substituted gearing is illustrated in Fig. 87, between the section and plan. For calculation purposes, it is dealt with according to rule previously given. Thus—

$$\frac{\text{Drivers}^{*}\ 33 \times 78 \times 78 \times 78 \times 4}{\text{Drivens}\ 50 \times 24 \times 19 \times 20 \times 3\frac{1}{2}} = 39.24 \text{ "Total draft."}$$

When making draft changes, it is customary in the trade to use " gauge points," which are useful in lessening the time taken in working out calculations and in favouring accuracy. As in the gill box, there is only one point at which changing is done—the " draft wheel " —the remaining unchanging factors may be reduced once and for all to their lowest point and the result obtained—the standard gauge point made use of in connection with the changing factor. Thus, in the preceding example :

$$\frac{\text{Drivers}\ 33 \times 4'' \times 40 \times 20 \times 30}{\text{Drivens}\ 50 \times 22 \times 18 \times 1 \times 3\frac{1}{2}''} = 1.385 \text{ St. G. P.}$$

Then G.P. × change wheel in use will give resulting draft,

or,

Draft required ÷ G.P. equals necessary change wheel.

* It is worth the trouble for the student to accustom himself to the names of the various wheels in the machine and the positions they occupy, so that he may calculate from data once obtained without further examination of the parts. Much saving of time may be effected by this means.

The reason for multiplying in one case and dividing in the other is worth noticing :

Multiplying by change wheel in the first case simply amounts to placing the absent factor (a " driver " and a multiplier) into its position occupied in the original calculation.

In the second example the G.P. is used to represent a draft wheel with one tooth giving a draft of one. Reasonably then for wheel required the G.P. should be divided into draft desired.

Modifications of the Preparer Gill Box.—Several attempts have been made to improve upon or supersede the ordinary gill box. In one case a graduated screw acting over a longer distance than in

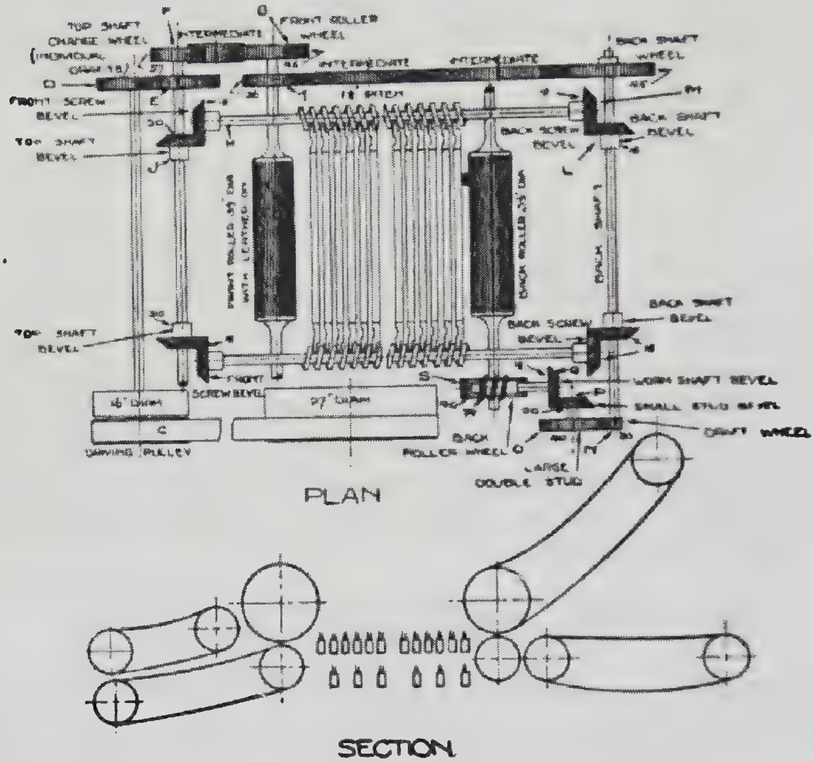


Fig. 89.—Plan and Section of the "Clough" Preparer-Box

the ordinary box was employed for driving the fallers, but as the fallers so propelled on falling from the slivers left bars of short fibres which they had collected, this arrangement never attained to any measure of success. More fortunate has been the idea of introducing two sets of screws and fallers (Fig. 89), so that there are three dis-

tinct drafts in the box—between back rollers and faller, fallers and fallers, and fallers and front rollers. Boxes of this construction may well form the first two of a set of, say, six preparers. The following are the drafting calculations for such a box:—

TOTAL DRAFT:

$$\begin{array}{l}\\ \text{Drivers} \\ \text{Drivens} \\ \\ \end{array}\begin{array}{c}\begin{array}{ccccccccc}\mathrm{I} & & \mathrm{O} & & \mathrm{Q} & & \mathrm{S} & & \mathrm{F.R.}\end{array}\\ \dfrac{45 \times 40 \times 18 \times 40 \times 11}{36 \times 30 \times 20 \times 2 \times 11}\\ \begin{array}{ccccccccc}\mathrm{H} & & \mathrm{N} & & \mathrm{P} & & \mathrm{R} & & \mathrm{B.R.}\end{array}\end{array} = 30$$

BACK DRAFT:

$$\begin{array}{l}\\ \text{Drivers} \\ \text{Drivens} \\ \\ \end{array}\begin{array}{c}\begin{array}{ccccccccc}\mathrm{L} & & \text{Pitch} & & \mathrm{O} & & \mathrm{Q} & & \mathrm{S}\end{array}\\ \dfrac{18 \times 1\frac{1}{8} \times 40 \times 18 \times 40}{18 \times 30 \times 20 \times 2 \times 11}\\ \begin{array}{ccccccccc}\mathrm{M} & & \mathrm{N} & & \mathrm{P} & & \mathrm{R} & & \mathrm{F.R.}\end{array}\end{array} = 2.45$$

MIDDLE DRAFT:

$$\begin{array}{l}\\ \text{Drivers} \\ \text{Drivens} \\ \\ \end{array}\begin{array}{c}\begin{array}{ccccccccc}\mathrm{G} & & \mathrm{I} & & \mathrm{M} & & \mathrm{J} & & \text{Piteh}\end{array}\\ \dfrac{45 \times 45 \times 18 \times 20 \times 1\frac{1}{8}}{27 \times 36 \times 18 \times 1\frac{1}{8} \times 18}\\ \begin{array}{ccccccccc}\mathrm{F} & & \mathrm{H} & & \mathrm{L} & & \text{Pitch} & & \mathrm{K}\end{array}\end{array} = 2.31$$

FRONT DRAFT:

$$\begin{array}{l}\\ \text{Drivers} \\ \text{Drivens} \\ \\ \end{array}\begin{array}{c}\begin{array}{ccccc}\mathrm{F} & & \mathrm{F.R.} & & \mathrm{K}\end{array}\\ \dfrac{27 \times 11 \times 18}{45 \times 20 \times 1\frac{1}{8}}\\ \begin{array}{ccccc}\mathrm{G} & & \mathrm{J} & & \text{Pitch}\end{array}\end{array} = 5.28$$

Then 2.45 (back draft) × 2.31 (middle draft) × 5.28 (front draft) = 29.8 (30 nearly) total draft.

For gauge point leave out draft change wheel (N) and proceed as before shown.

These boxes are not now used to a great extent, their place having been taken by what may be described as "cott boxes" for opening specially "cotty" wool. One reason for this is that the initial cost is great, and changes are very difficult to make. For mohair, however, these boxes seem specially appropriate.

The Carder.—The carder, as adapted to the preparation of the medium and short combing wools, usually consists of opening rollers or of a breast, serving partially to open the wool prior to the more severe carding effected by the swift proper, and two swifts each with three workers and strippers, a fancy, a doffer, and certain accessory rollers, such as the "dickey" for cleaning and clearing cylinders, the burring rollers for removing

DETAILS OF WORSTED CARDERS

(*a*) Fine Qualities—Merino Wool

Cylinders	*Number*	*Diameters* (inches)*	*Revolutions*	*Surface Speed per minute*	*Clothing, Counts and Crown*	*Pins per sq. inch*	*Size of Pins*
Feed Rollers	2	3	·25	0·195	} Needle	point	steel
Clearer Roller. . . .	1	2½	·66	0·43	} wire, s	trong	fillet
1st Licker-in	1	30	6·25	49·49			D.P†
2nd "	1	24	25	163	90/9	324	28
3rd "	1	24	50	327	100/10	400	30
4th "	1	24	100	654	115/10	460	32
1st Divider	1	20	2·1	11·52	70/6	168	25
2nd "	1	12	3·6	12·17	90/9	324	28
3rd "	1	12	3·9	13·27	110/10	440	30
4th "	1	12	4	13·6	120/10	480	32
Burring Rollers . . .	6	4½	600	666			
1st Swift	1	50	100	1335	130/12	624	33
1st Workers	1	12	3·3	11·23	135/12	648	34
2nd and 3rd Workers .	2	12	—	—	140/12	672	35
1st Strippers . . .	3	7	195	280	110/10	440	31
1st Fancy	1	12	376	1171·58	80/8	256	31
1st Doffer	1	40	5	54	140/12	672	35
Angle Stripper . . .	1	7	195	280	120/10	480	31
2nd Swift	1	50	115	1535·45	150/13½	810	35
4th Worker	1	12	3·3	11.23	150/13½	810	35
5th and 6th Worker .	2	12	—	—	155/14	868	36
2nd Strippers . . .	3	7	222·25	322	115/10	460	32
2nd Fancy	1	12	432·4	2037	90/8	288	33
2nd Doffer	1	40	5	54	155/14	868	36

* Diameter of cylinder unclothed.
† Birmingham wire gauge

burrs, etc. On p. 216 and below are the cylinder dimensions, speeds and clothing of a standard worsted carder for (*a*) Fine Botany wools, (*b*) Medium Cross-bred wools, and (*c*) Lustre wool and hair, the contrasting of these three supplying the data for carding the intermediate qualities of wools.

DETAILS OF WORSTED CARDERS

(*b*) MEDIUM QUALITIES—CROSS-BRED WOOL

Cylinders	*Clothing*	*Pins per sq. inch.*
Feed Rollers (2) Clearer Roller (1)	Needle point steel wire.	
1st Licker-in	Garnetted.	
2nd ,,	60/6	144
3rd ,,	80/8	256
4th ,,	100/10	400
1st Divider	60/6	144
2nd ,,	80/8	256
3rd ,,	90/9	324
4th ,,	110/10	440
1st Swift	110/10	440
1st Workers (3)	115/10	460
1st Strippers (3)	80/8	256
1st Fancy	70/6	168
1st Doffer	115/10	460
Angle Stripper	100/10	400
2nd Swift	125/12	600
2nd Workers (3)	130/12	624
2nd Strippers (3)	90/9	324
2nd Fancy	70/7	196
2nd Doffer	130/12	624

(*c*) LONG LUSTRE AND MOHAIR QUALITIES

Cylinders	*Clothing*	*Pins per sq. inch.*
Feed Rollers (2) Clearer Roller	Needle point steel wire.	
1st Licker-in	Garnetted.	
2nd ,,	30/6	72
1st Divider	30/6	72
Breast	40/6	96
Breast Workers (2)	45/6	108
Breast Strpprs. (2)	30/6	72
Angle Stripper	60/6	144
1st Swift	70/7½	210
1st Swift Workers (3)	80/8	256
1st Swift Strippers (3)	70/6	168
1st Fancy	60/5	120
1st Doffer	90/9	324
2nd Angle Stripper	80/8	256
2nd Swift	115/10	460
2nd Swift Workers (3)	120/10	480
2nd Swift Strippers (3)	80/8	256
2nd Fancy	70/6	168
2nd Doffer	120/10	480

Seeing that the maintenance of length is such an important matter in worsted spinning, the gradual speeding up of the rollers from the first opener to the last doffer is worthy of more than passing comment.

Perhaps the carding overlooker is still too conservative in setting his machines, and if so it is probable that cylinder speeds is one of the matters calling for careful consideration. At least, he should not be too much under the influence of the machine maker—he should know "why."

In Fig. 90 the relative actions of the various cylinders are indicated.

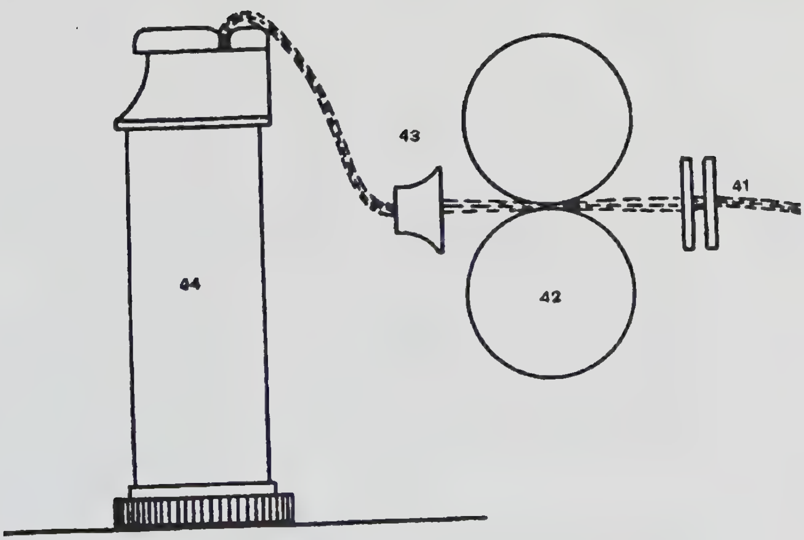
1. Fed on to the sheet by hand (6)—or, as is more general, by an automatic feed (1)—the wool is carried by this into the feed-rollers (7). The teeth of these are set in the direction opposite to that in which the rollers move, so as to effect some opening of the staples when these are seized by the upward pointing and upward moving pins of the first licker-in (8) on to which they are run. To ensure the complete transference of all material, a third feed-roller *7a* is employed which strips the top feeder, and, owing to the upward setting of the feed-roller teeth, no staples will be carried round the bottom feed-roller. The third feed-roller is in turn stripped by the licker-in by a point to smooth-side movement. Then come the following movements:—

2. Opening by point-to-point action of 1st divider (12) on 1st licker-in—material left on 1st divider.*

3. Stripping by point to smooth-side action of 2nd licker-in (9) on 1st divider and 1st licker-in—material left on 2nd licker-in.

4. Opening by point-to-point action of 2nd divider 13 on 2nd licker-in—material left on 2nd divider.

* It should be noted that the clothed cylinders intercept and open only such material as is not sufficiently disentangled to pass through them. This accounts for the stripping, which takes place between the 2nd and 1st licker-in as well as between the 2nd licker-in and 1st divider: material opened has been left on the 1st divider; material not opened at this stage has been carried round by the 1st licker-in for removal by the 2nd licker-in.



43
41
44
42

5. Stripping by point to smooth-side action of 3rd licker-in (10) on 2nd divider and 2nd licker-in—material left on 3rd licker-in.

6. Opening by point-to-point action of 3rd divider (14) on 3rd licker-in—material left on 3rd divider.

7. Stripping by point to smooth-side action of 4th licker-in (11) on 3rd divider and 3rd licker-in—material left on 4th licker-in.

8. Opening by point-to-point action of 4th divider (15) on 4th licker-in—material left on 4th divider.

9. Stripping by point to smooth-side action of swift (19) on 4th divider and 4th licker-in—material left on swift.*

10. Working by point-to-point action of worker (21) on swift—material left on worker.

11. Stripping by point to smooth-side action of stripper (22) on worker—material left on stripper.

12. Stripping by point to smooth-side action of swift on stripper—material left on swift.

3 times

19. Raising by smooth-side to smooth-side action of fancy (27) on swift—material left on swift.

20. Opening and clearing by point-to-point action of doffer (28) on swift—material left on doffer.

21. Stripping by point to smooth-side action of angle stripper (30) on doffer—material left on angle stripper.

22. Stripping by point to smooth-side action of 2nd swift (29) on angle stripper (30)—material left on swift.

* Something similar happens with the material on the swift. The 1st. worker opens that which is unable to pass it (the remainder going on to succeeding workers). It is removed by the stripper, and afterwards taken up by the swift (already partially charged with material from the feed-rollers, but still capable of effectively stripping) and carried this time past the worker. It is, of course, separated at this point from that which is matted—the last taken up from the feed-rollers.

23. Working by point-to-point action of (31) worker on 2nd swift—material left on worker.

24. Stripping by point to smooth-side action of stripper (32) on worker—material left on stripper.

25. Stripping by point to smooth-side action of swift on stripper—material left on swift.

3 times

32. Raising by smooth-side to smooth-side action of fancy (37) on 2nd swift—material left on swift.

33. Opening and clearing by point to smooth-side action of doffer (38) on 2nd swift—material left on doffer.

34*. Stripping of material in film form from doffer by doffing comb (40), this being later conducted through calendar rollers (42) into funnel (43), by which it is condensed into sliver form and taken in coiler cans (44).

It was about the middle of the last century that the first attempts were made to prepare wool for combing by carding it. A cursory survey of carding would lead one to the conclusion that no worse method of preparation for combing could be devised. A more careful consideration of carding, however, would lead one to the opposite conclusion, and to-day it is quite customary to prepare wool 8 to 10 inches long for combing by this means.

There are several details respecting the worsted carder which require careful attention. In the first place, automatic feeds should claim consideration. In these days of scarcity of labour and high wages every machine is rendered as automatic as possible, and the carder is no exception to the rule. The automatic feeder, however, is not a process for the long wools, as length seems to interfere with its regular action. On short wools also the hopper should be kept filled or staples will "string."

* *See* "Wool Year Book." Marsden & Co.

Many wools come up from the washing charged with burrs, and some wools required "clear" are "kempy." The first difficulty is got over by fixing burring rollers or beaters to work in connection with the opening rollers, as shown in Fig. 90. Usually six are employed, these being set in twos over the first licker-in and the two top dividers. They are steel-bladed rollers, revolving at from 600 to 800 revolutions per minute, and their action depends on the inability of the curled-up burrs to penetrate, as is possible in the case of the wool, below the surface of the cylinder's card clothing. The wool is firmly held, but the burrs, along with a small portion of the fibre to which they cling, are broken away by the burr beaters and deposited in trays to be collected at intervals. This method, however, cannot be employed on wools which are heavy in burr; it is not sufficiently effective.

In other cases the grinding of the vegetable matter into small pieces is attempted, with the idea that in subsequent processes continued movement of the fibre will complete the removal of the impurity. A well-known and largely used type is the Harmel burr-crushing apparatus, which is set midway in the carder, at a point where the fibre leaves the first doffer. By this means both wool and burrs are opened somewhat when presented to the burr appliance, and this condition admits of the thicker and more brittle burr being crushed while the fibre is expected to escape this action. Stripping for this treatment is effected on the doffer by a doffing comb; the material, in film form, then passes over a supporting plate and over a plain steel roller, on which two sharply fluted rollers of varying pitch are pressing, for the purpose of crushing; from this it is taken by way of angle roller to the second swift. Continued crushing chokes the fluted rollers with impurity;

to remove this, fluted clearer rollers, set above but in actual gear with the crushers, are traversed continually so as to scoop out the foreign matter, later depositing it into cans.

In many machines a fluted roller is part of the calendar head by which the sliver is conveyed to the coiler can. The object of this is to give a second crushing to any burr that may be found in the now fully opened fibre. Such action, however, is somewhat severe on the wool fibre, especially if the fibre is hard and inelastic; consequently its use is not to be commended.

The final separation of the finely divided burr takes place in the comb, when its removal is effected along with the noil. Noils produced are consequently less attractive, being "burry," than is the case when the ordinary burr roller is employed. Still, the saving effected through preserving all the wool fibre for either top or noil amply compensates for any deterioration of noil caused.

"Morel" Burring.—A motion which is extremely effective in producing a "clear" top is known as the "Morel" burring mechanism, an arrangement for which Wool-Combers' Limited hold the sole rights in this country. The chief feature is the "Morel" roller, which is densely clothed with specially made "Garnett" wire, its character being such that wool placed upon it may be held completely and tenaciously in the teeth, while the burrs—too thick to penetrate the pins—stand on the surface. A steel-bladed and quickly revolving burr beater then breaks the burrs away, driving them into a tray from which they are removed by scrapers. The wool comes to the "Morel" roller from the first licker-in, on which it has been effectively opened by the "Garnett" teeth of the roller working against the teeth of two

smaller " workers " similarly clothed. A quickly revolving brush does the necessary stripping from the licker-in; it also fixes the wool into the teeth of the burring roller. After treatment, stripping of the " Morel " is accomplished by the second licker-in; the wool is then taken to the second divider, and then direct to the first swift. The third and fourth lickers-in and dividers may be dispensed with when this motion is used, owing to the thorough opening of the fibres given prior to and during the process of burring.

The kemps referred to are usually thrown out during carding, and arrangements should be made under the card to ensure that, once thrown off, they never have the chance to get into the wool again. Thus the control of air blasts on the carder is by no means unimportant.

The grinding of the clothing on a carder must be very carefully undertaken if the card is to work to the greatest advantage.

Processes following Carding.—It will readily be understood that the sliver coming from the carder consists of a jumbled-up mass of fibre in comparison with the straight-fibred sliver issuing from the last preparing box. It will, perhaps, also be realised that not only will the mass of material be somewhat sullied from passing through the carder, but, further, that as fibre will have been most thoroughly separated from fibre, dirt, which the first scour could not get at in the washing-bowls, will now be in evidence.

It thus comes about that carding is usually followed by—

(*a*) Backwashing; (*b*) Gilling.

It will further be evident that if a thorough cleansing of this sliver is attempted, whiteness will be

expected. As this is not always in evidence to the extent desired, " blueing " is resorted to, powder blue or blueing agent being added to the rinsing or some other bath of the backwasher to impart to the " top " an artificial whiteness. It is probable that the top is not damaged, but it is certainly not really improved by this, so that, upon the whole, blueing must be regarded as an unnecessary practice. And here the English comber is inconsistent, for having got his tops clean, he at once proceeds to add up to 3 per cent. of oil to facilitate combing. Oiling is usually effected on the gill box following the backwasher, so that during the following two or three processes the oil may be thoroughly distributed throughout the sliver. Thus the English comber " combs in oil." The French comber, on the other hand, largely because he uses the French or Heilmann comb, usually " dry combs," and very often places backwashing after combing, so that he produces a " dry " top suitable for " dry spinning." With his sequence of machines, however, he can comb dry, or comb with a small proportion of oil, and still deliver a " dry top " by backwashing after combing.

The Backwasher—This machine primarily consists of a two-tank scouring device, a drying apparatus, an oiling apparatus (if required), and a balling gill box. The general disposition will be understood from Fig. 91, in which both plan and elevation are given. The first tank contains a light scouring liquor, in which the slivers are suitably immersed. The liquor is usually made in the proportion of 2 gallons of soap liquid to 50 gallons of water. The soap liquid is made of 1 lb. of soap (hard or soft) dissolved in 1 gallon of boiling water.

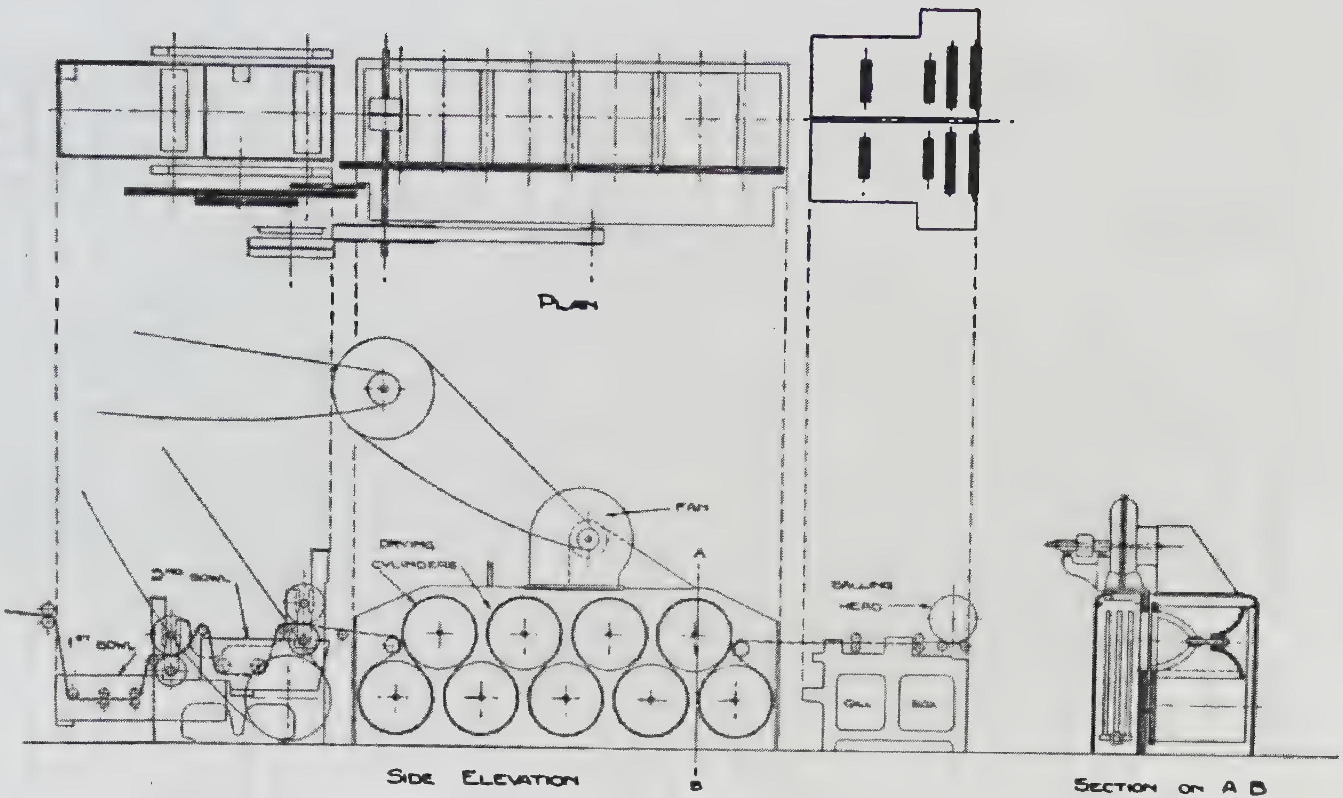


Fig. 91.—Backwashing Machine

The second tank contains the rinsing liquor, charged with the blueing agent. After passing through the squeezing rollers, the slivers pass through the drying apparatus. Until within the last eighteen months this usually consisted of a few large or a number of small steam-heated cylinders. Now, however, this method of drying has been dispensed with; perforated cylinders are employed which allow dry air to be blown through the slivers, so that air-drying may now be taken as the universal practice. This change may seem a detail, but it is one which every comber of note is having to adopt, simply owing to the better yield of top and the quality difference it results in.

The gill box which follows the drying cylinders is of the usual type, save that it may be necessary to have it designed with two heads to take the large number of slivers passing through the machine. An oiling motion of a simple type allows oil to drop on to the slivers during the passage between back and front rollers. The following are the usual percentages for the different qualities of wool:—

Down Wools	$2\frac{3}{4}$ per cent.
Merino Wools	3 per cent.
Long Wools	$3-3\frac{1}{2}$ per cent.

Following the backwasher come one or two gill boxes—"strong boxes," as they are termed—their function being further to straighten out the fibres and open neps, so that prior to combing all the fibres in the sliver are fairly parallel, this ensuring efficient combing with the least possible breakage of fibre and the greatest possible yield of "top" (Figs. 92, 93 and 94).

It should here be noted that the sliver coming from a carder possesses a definite and interesting arrangement of fibres. If broken straight from the carder

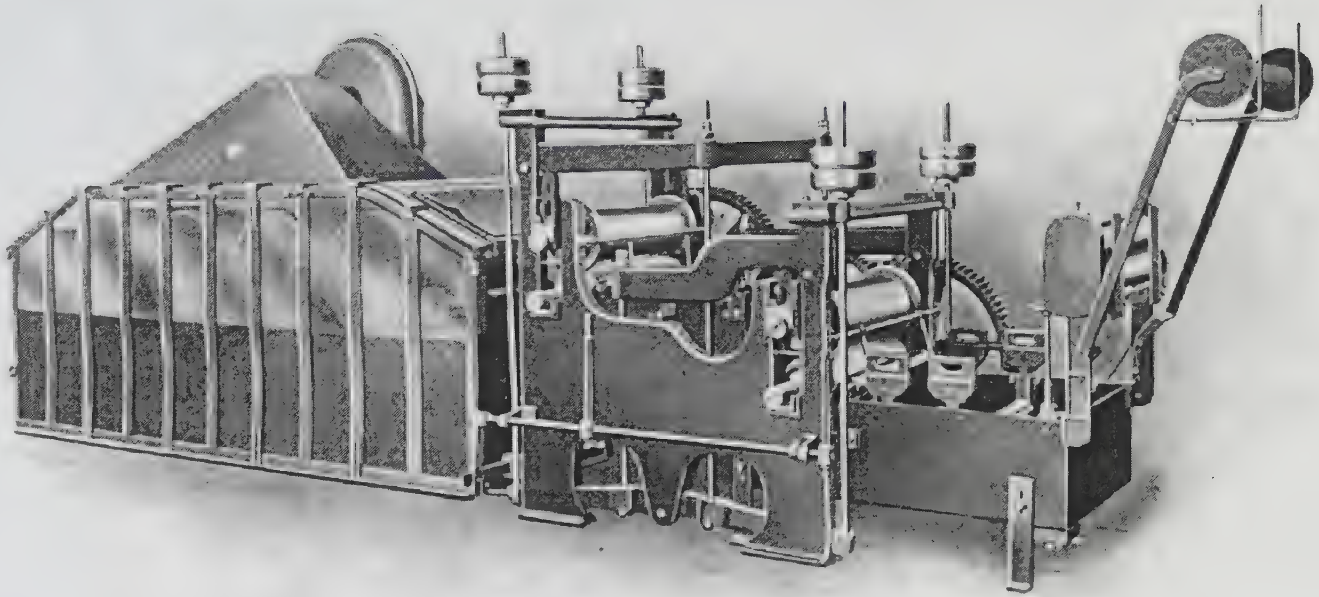
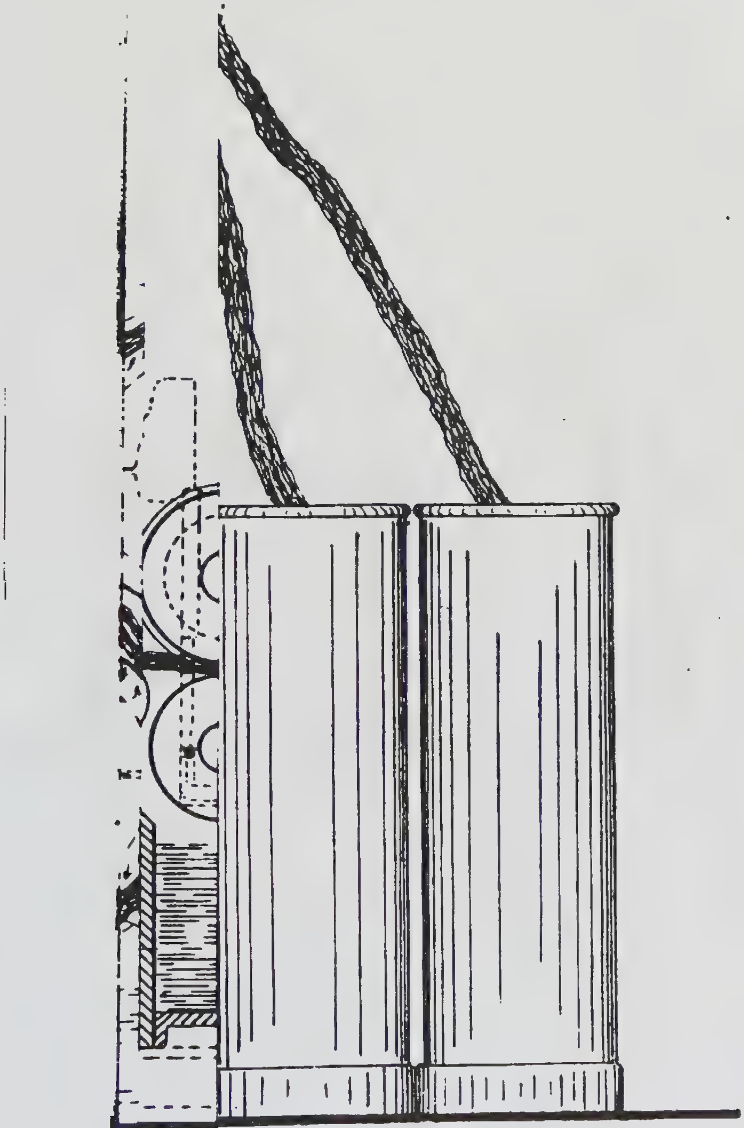


Fig. 92.—Backwasher



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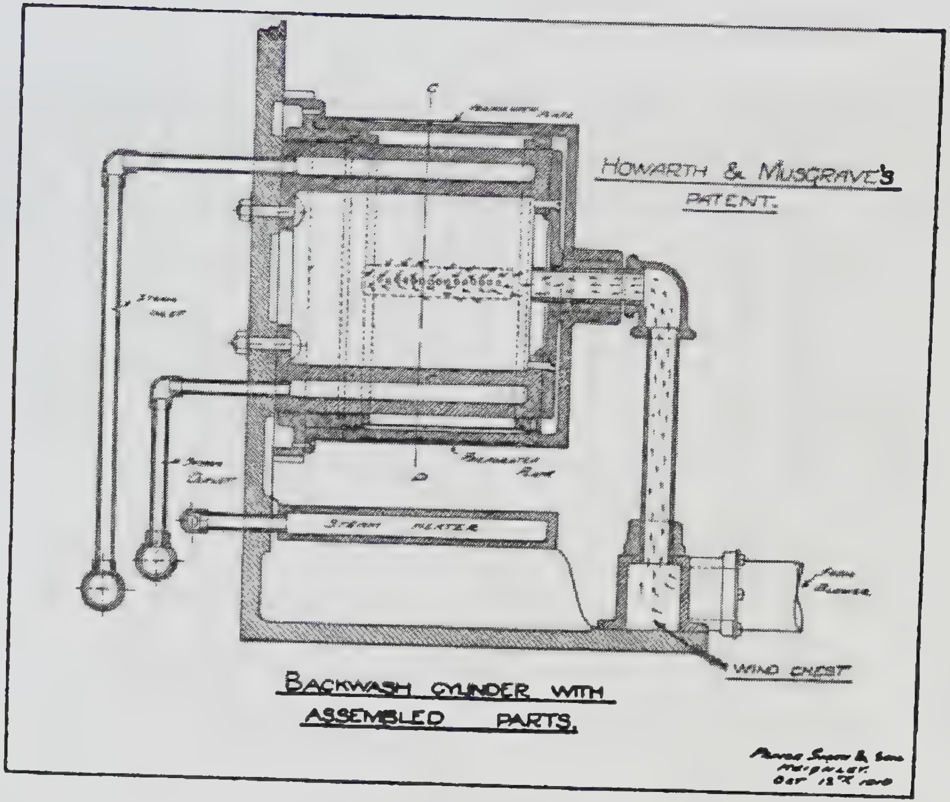

HOWARTH & MUSGRAVE'S
PATENT.
STEAM HEATER
WIND CHEST
BACKWASH CYLINDER WITH
ASSEMBLED PARTS.

Fig. 94

it will be noticed that one hand retains the neps and short fibres while the other is quite free. This peculiar arrangement once present is never entirely eliminated; to comb to the greatest advantage, therefore, there should be two reversings only, so that the slivers are fed into the comb just as if they were fed out of the can-coiler from the carder. This is another example of the necessity for a close study of the many problems involved in the textile industry, the satisfactory solution of which must be effected if lasting success is to be achieved.

CHAPTER X

COMBING, RECOMBING, AND FINISHING

In Chapter VIII the various types of worsted and woollen yarns were fully considered. The object of thus studying the result, prior to studying the means of obtaining the result, will now be apparent. For the comber who simply combs without due consideration of the type of result required for the yarn into which his tops eventually have to be converted, will certainly secure only a partial success. Realising the difference between one extreme—the mixed, cloudy, woollen yarn—and the other extreme—the straight, clear worsted yarn—the truly practical comber can produce the top required for the desired yarn, and thus indirectly aid both spinner and cloth constructor in attaining the final desired result. A simple example will render this clear. In two respects the French upright vertical comb may be said to be an improvement on the Noble comb: first, it will leave shorter fibres in the "top," thus giving a greater yield of "top," and secondly, other things equal, it will yield a clearer "top," free from neps and other blemishes. In the spinning of fine black and white twist yarns blemishes in the white are so magnified that the least defect is an eyesore. Top for this yarn is combed on the French comb. But the possibility of leaving more "short" in the "top" for these yarns is not taken advantage of; in fact, it

would be a positive disadvantage. The superior clearing quality of this comb, however, is taken advantage of, with most happy results. Points such as this should claim the thoughtful consideration of every comber.

General Principles of Combing.—There are three main factors involved in combing: first, the straightening of the fibres treated; second, the equalising of the fibre length; and third, the removal of all neps and blemishes of whatever nature they may be. In the hand-combing of English wools the straightening process was dominant. Thus the first time combing was spoken of as "jigging" and the second time combing was termed "straightening." No doubt, in the days of hand-combing wools of more regular fibre length were dealt with than is the case to-day, the straightening of the fibres being the *raison d'être* of the process. But even then fibres were broken and twisted round the comb-teeth, thus necessitating the removal from the front, back and points of the pins of "milkings," "backings," and "noil." To-day "straightening" must be regarded as the necessary condition involved in every combing process; thus, first-combed tops, being more or less disturbed by "slubbing-dyeing," must be straightened by a second filling and combing operation. The equalising of the fibre length is now more than ever necessary in view of the blending of wools which obtains in the worsted industry. Of course, blending is most readily effected in the gill-boxes forming the first part of a set of drawing machinery; but blending in the wool state and on the combs is not unknown, hence the necessity for some sort of equalisation if a good spin is to result. But again it is evident that the comber must use his judgment as to what he

takes out as noil. In some cases straightening only may be required, with as much short fibre as possible left in; in other cases the really long fibres only may be required in top, as much noil as possible being taken out. As a rule, of course, the comber is judged by the percentage of top he can produce from a given blend of wool; but there is reason to believe that something more will be expected of the comber in the near future. The removal of "neps" and other blemishes should be a main point in every combing operation; in fact, so necessary is this in dealing with certain burry wools that it is customary to take a fixed length of top and count the blemishes, and then by comparison judge of the efficiency of the combing.

One or two other points respecting the principle of combing should here be noted. In the case of mohair combing for dolls' hair, combing follows combing several times, as an equalising of the fibre length is the whole *raison d'être* of the process. In combing Iceland wool, camel-hair, etc., the operation is undertaken with the idea of separating the shorter and more valuable fibre from the longer and stronger hair. In the case of combing silk and China-grass on the Noble comb, the chief difficulty is created by the slipperiness of the fibres; thus in this and most types of combing the surface friction between fibre and comb-pins is a factor to be taken into account.

Yields in Combing.—It will be obvious that different wools and blends will yield different proportion of "top" and "noil." This yield is spoken of as the "tear." The following list gives an idea of what may be expected from the Noble comb. As already indicated, the French comb may be set to give more or less noil as desired, hence these approximations

are not wide enough for this more recently introduced comb:—

APPROXIMATE PROPORTIONS OF TOP AND NOIL FOR NOBLE-COMBED WOOLS

Type	*Quality*	*Proportion of Top and Noil in Scoured Wool*	*Percentage of Noil from Greasy Wool*
ENGLISH WOOLS:			
1. Long Lustre . . .	28's–44's	10 to 1–16 to 1*	7–4½
2. Medium Lustre .	46's–50's	11 to 1– 8 to 1	6–8
3. Short Down . .	50's–56's	10 to 1– 7 to 1	7–10
CROSS-BRED WOOLS:			
Australian and New Zealand:			
4. Low	32's–44's	14 to 1–10 to 1	5–6½
5. Medium	46's–50's	11 to 1– 9 to 1	6–7
6. Fine	50's–58's	10 to 1– 7 to 1	5½–7½
7. South American —(" Buenos Ayres," etc.)†	Qualities similar, but amount of noil from 1 to 3 per cent. more		
MERINO WOOLS:			
8. Australian—average	58's–64's	9 to 1–5 to 1	4½–8
9. " —super .	70's–90's	7 to 1–8½ to 1	6½–5
10. Cape	64's–70's	4 to 1–7½ to 1	7–4
11. South American —(Monte Video) . .	60's–64's	4 to 1–7 to 1	10–6

* In English wools the bigger "tear" (*e.g.*, 16 to 1) refers to the better qualities. With qualities higher than these the amount of top decreases as quality increases up to, say, 64's. Beyond this the wools are so uniform that although the maximum noil has to be removed in order to spin the fine counts of yarn, the proportion of noil does not increase.

† These wools are often combed, especially for the hosiery yarn trade. In such cases markedly soft and full yarns are required from these rather than smooth yarns of fine counts, and consequently much short otherwise removed as noil is left in the top.

Top Costing.—As the only operations to follow combing are two finisher-box straightenings, top costing may here conveniently be dealt with.

The following example will serve to show the factors which influence price. Suppose 70 packs (240 lb. =

1 pack) of Merino wool are combed, the "result" may be—

	Lb.		Per cent.
Top . .	7,603	or	44.82
Noil . .	920	,,	5.42
Shoddy . .	72	,,	.43
Burrs . .	60	,,	.35
Sinkage . .	8,310	,,	48.98
	16,965		100.00

giving a proportion of top to noil of 8.2 to 1.

The sinkage, which comprises grease, dirt and fibre which cannot be collected, is, of course, absolute loss. The burrs (extracted during carding) and the shoddy (waste produced during carding) are worth little, say 1d. and 2d. per pound respectively; when sold they have, therefore, only a slight cheapening influence on the top, which, in estimations at least, it will be well to ignore. Noil, however, may be sold and the income utilised in meeting the combing charges, which are invariably based on the weight of top returned to the owner. Thus there would be 16,965 lb. greasy wool at, say, 13d. per lb., costing £918 18s. 9d., to which must be added the difference between 920 lb. of noil worth, say, 16d. per lb., and the combing cost of 7,603 lb. of top at 2½d. per lb., the answer to this being £928 17s. 5d., the actual cost of 7,603 lb. of top, or 29¼d. per lb.

When buying wool for combing purposes it is usual to make estimates of the yield of scoured wool in a given lot and the proportion of top and noil likely to result. These, along with the estimated noil value and the combing charge (obtainable from any woolcomber's list) enable, on the one hand, the approximate stand-in cost of the top to be obtained or, on

the other, the value of the wool for a given price of top to be arrived at by simple calculation.

For Example.—Wool worth 13d. per lb., yield (top and noil) 51 per cent., "tear" (top and noil) 8 to 1, noil value 16d. per lb., combing charge 2¼d. Find cost of top.

100 lb. greasy wool at 13d. per lb. = 1,300d.
Yield 51 per cent., tear 8 to 1:
Therefore $\frac{8}{9} \times 51 = 45\frac{1}{3}$ lb. top at 2¼d. per lb. for combing, or . . . . 102d.
And $\frac{1}{9} \times 51 = 5\frac{2}{3}$ lb. noil at 16d. per lb., or 90⅔d.

Noil underpays * 11⅓d.

Thus 1,300d + 1⅓d. = 1,301⅓d. for 45⅓ lb. of top, or 28.7d. per lb.

Or to find the value of the wool:

Value of top	28¾d.
Combing Charge	2¼d.
Cost of scd. wool—varying top and noil	26½d.

Tear 8 to 1; then $\frac{8}{9}$ (top) × 26½d. = $23\frac{5}{9}$d.
Add $\frac{1}{9}$ (noil) × 16d. = $1\frac{7}{9}$d.

Actual scoured wool value . . 25⅓d.

The yield is 51 per cent.

$$\text{Then } \frac{25\frac{1}{3} \times 51}{100} = 13\text{d. (nearly †).}$$

* If noil overpays combing, the difference must be subtracted from the cost of 100 lb. of greasy wool.

† The slight discrepancy in the results of the two examples is due to the neglect of fractions in the case of the first.

Types of Mechanical Combs.—There are two types of mechanical comb, dating from the days of Dr. Cartwright—the Vertical Circular and the Horizontal Circular. Curious to relate, the French specialised on the Vertical Circular, possibly owing to its suppression in England by the late Lord Masham, while the English specialised on the Horizontal Circular. To-day the

French frequently use the English type when it better serves the purpose in view, and the English use the French type in like manner.

The Vertical Circular Comb.—This is generally spoken of in the trade as the Heilmann's. There are several types made by three or four Continental makers, and by at least one English maker under licence from the Continental firm. This type of comb has always dominated the cotton trade, so that in its other form most of the Lancashire spinners are familiar with it.

The adoption of this machine in this country so far is greatest in connection with fine wools; the comb, however, may be applied on the longer qualities, and most likely will be as the demand increases for soft-handling yarns. Although in matters of production the comb is distinctly below other types competing with it, it yields important advantages. In addition to those already mentioned, the comb is the best at present available for "dry-combing"—i.e. combing without oil on the wool—for owing to the greater control of the fibres which is possible in this machine, heat (necessary in other combs but which makes oil-less fibres far too active) may be dispensed with. Then for "burry" wools this comb is particularly serviceable. By a special knife working on the circle the burrs are thoroughly separated from either top or noil fibres and deposited in a chamber made specially for the purpose. The noil is also kept free from dust and from the very short "shoddy" fibres, and is thereby made much more attractive and valuable.

The following description of the Vertical Circular, or Rectilinear Comb, as it is termed, applies more particularly to the machine made on the Continent by the Société Alsacienne of Mulhousen and in this country by

Messrs. Prince, Smith and Son, of Keighley. Other types are the Schlumberger, of the Schlumberger Co., Gebweiler, Alsace, and the Dilette or Offermann-Grun, made by A. Grun of Lure; but in all cases the principle is the same, constructional details forming the modifica-

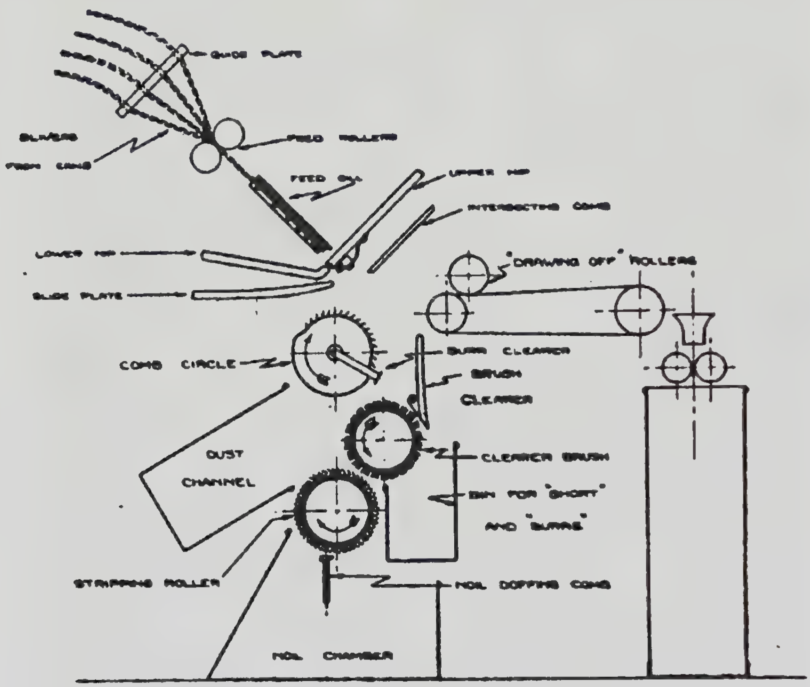


Fig. 95.—Vertical Circular Comb

tions to be noted. Generally twenty-four slivers are employed of about 1½ oz. per 5 yards, and the feeding is done from cans. On the Continent lap feeding (which requires special preparation) is common with the shorter wools, as it is considered that better control of the fibre is possible with this arrangement. In either case the slivers go through feed rollers, a feeding gill, and a

nipper to the comb circle, as is shown in Fig. 95. The feeding gill, as will be noted from the diagram, consists of three plates: a lower, which is grooved; one in the middle, which is slotted; and the top one, fitted with rows of pins to engage the spaces underneath and to hold fairly tightly any wool fed between the latter. This plate does not prevent, however, any long fibres being drawn through the feed plates; indeed, part of its function is to act as clearer. The nipper is a pair of jaws, and in front of the top one is a brush arranged so as to press down the wool, which may be held firmly by it on to the comb cylinder which is working below. To the feed gill and feed rollers a traversing movement is given; and thus while the wool is held in the nipper these may be moved back along the sliver, and in this way prepare a fresh supply of wool to be brought forward by the return traverse as the nip opens. Such movement, though apparently complex, may be effected both conveniently and accurately by an arrangement of cams and springs which, however, there is not space here to describe. The comb circle is fitted, over one half of its circumference, with about eighteen rows of pins tangentially set and perfectly graded in size and density, and thus on revolving it combs easily but completely the tuft of wool projecting from the nip. The remaining part of the cylinder is leather-covered and serves to effect the drawing away of the fibres along with a slide bar and a pair of rollers, the latter being mounted with a delivery-sheet and supporting rollers on movable arms. By the oscillation of these parts hereby possible the tufts drawn out are carried towards the can containing the combed top, in order to make way for repeated combing action. Still, continuity is established between the various tufts for the reason that the rollers have not delivered one tuft before their

traverse is completed and they are back again at the nip to take up and link up the material there available which is just combed. To obtain perfect clearance when drawing off takes place an intersecting comb is necessary for that part of the tuft held in the cup. This fits above the nip, but during drawing off it is made to penetrate the web of fibres and hold back any "short" while the long fibres are carried forward.

Under the comb cylinder is a brush which, on revolving, removes the short fibre left in the comb pins. A rising and falling motion is given to this, so that an action on the leather-covered part of the cylinder will be avoided. Working on the brush is a roller fitted with card-clothing or filleting; this strips from the brush the noil fibre, which is in turn cleared by a doffing comb, to be later deposited in the noil chamber. On the brush continuing its revolution, the shorter and dusty fibre is also separated and placed in a special box in front of the comb.

DETAILS OF RECTILINEAR COMB

Comb Circle	*Feeding Gill*	*Intersecting Comb*
Diameter of circle, 6⅛ in. Set-over, 7¼ in. Rows of pins, 18 Length of pins, 9/16, ½, 7/16 in. Pins per inch — first row, 11 Pins per inch—last row, 64	Set-over, 3¼ in. No. of rows of pins, 8 Pins per inch per row, first row, 20 flat, second to seventh rows inclusive, 18; eighth row, 16 Length of pins, ⅞ in.	Set-over, 15¼ in. Pins per inch, 68 flat Length of pins, ⅝ in.

This comb is specially adapted to the combing of the finest and shortest wools, yielding a top second to none for clearness and openness.

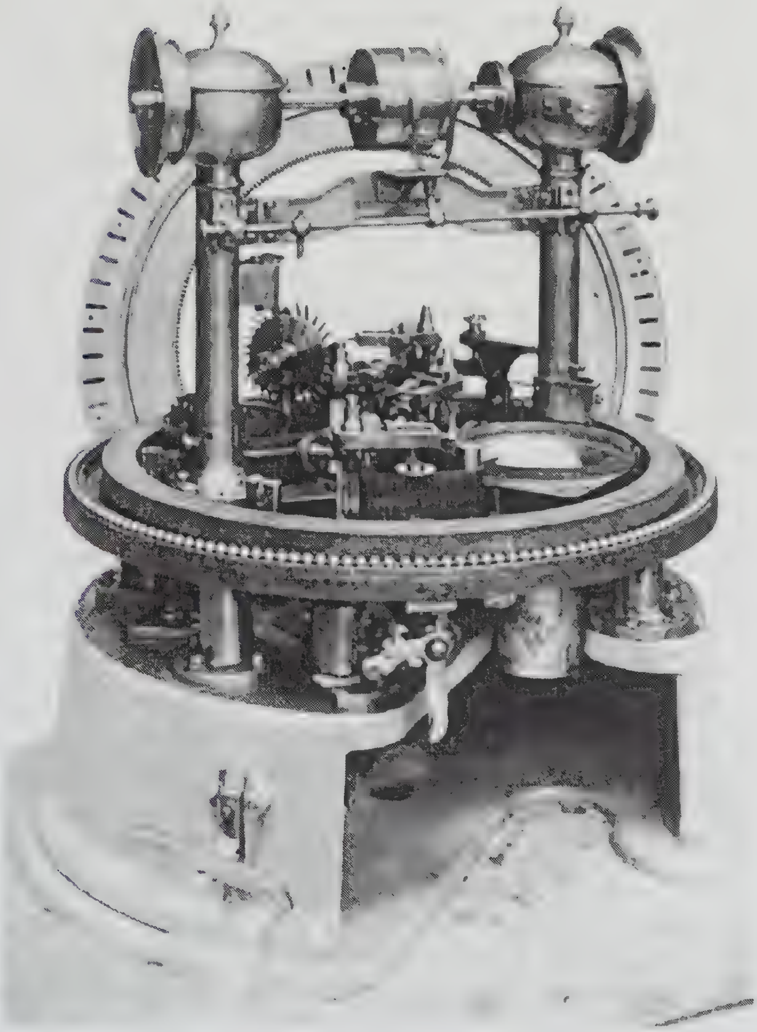


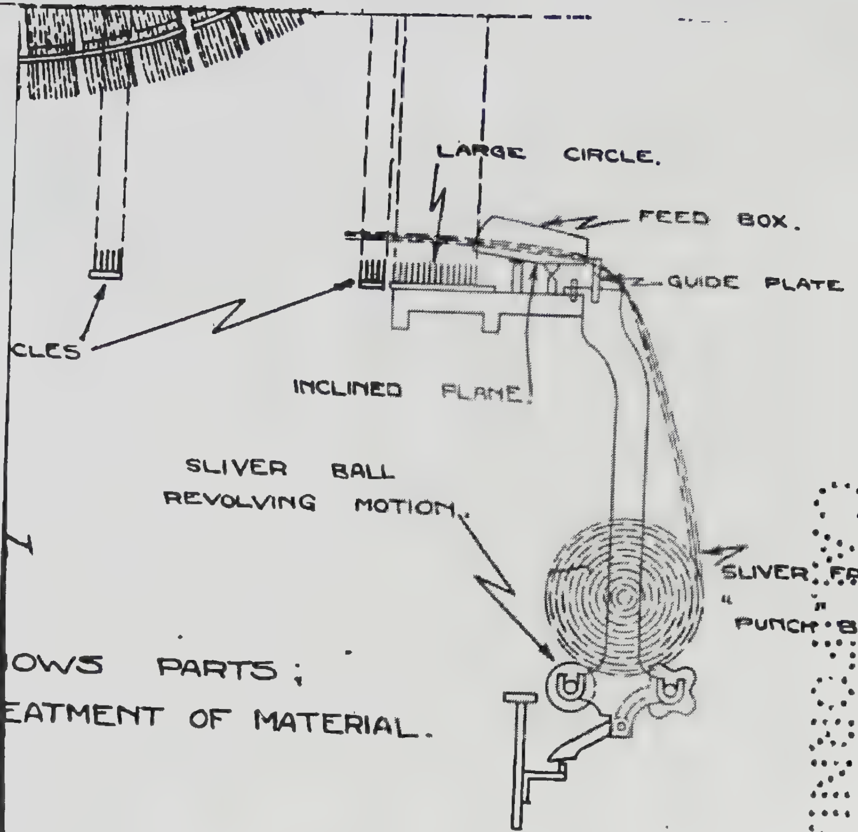
Fig. 96.—The Noble Horizontal Circular Comb

The Horizontal Circular Comb.—There have many types of this comb, of which three at present dominate the English combing industry, viz. the Noble, the Nip, and the Square Motion. As the Noble is the most universal and useful comb of the three, it must here be considered most fully and the others described by contrast with it (Fig. 96).

Briefly stated, combing is effected in the Noble comb by the circles vertically pinned, which work in conjunction with each other, and also by means of drawing-off rollers. As the particulars given hereafter show, these circles vary in pin arrangements both as regards number of rows, size and density, according to the class of wool for which the comb is fitted. One of these circles is large, being $42\frac{7}{8}$ inches diameter inside measurement; the two smaller circles, which are 16 inches measured over all, are placed inside the larger one, one at each side, and all three are positively driven. Wool in sliver form is placed over the circles at the point where the large one is in contact with the two smaller, and pressed into the pins by a dabbing-brush. As shown in Fig. 97, in which the right-hand side of the plan and elevation represents the comb charged with wool, and the left-hand side the working parts, continued revolution of the circles immediately separates the parts in contact; each comb then holds the parts of the fibres it is capable of retaining, and draws the remaining portion of the longer ones through the pins of the comb working with it, and in this way effects a clearance of these at one end. Combed fringes are in this way formed—an outside one on the smaller circles and an inside one on each side of the large circle, and these, on being drawn off by rollers, are further cleared at their opposite ends. Four ends of top are thus produced; these are conducted into a funnel at the centre

of the comb, and from this run into a coiler-can, false twist being employed to impart the necessary strength. The short fibre (noil) left in the circles is cleared from the *smaller circles only* by triangular-shaped noil-knives fixed between the rows of pins; these, as the circles revolve, lift the noil clear, and, due to the knives being graded in size, they tilt it over the side of the circle into a can or shoot. In the large circle the short fibre is blended with the long, and therefore the lifting of the sliver farther over the circle, so that the end can overlap the small circle working on the opposite side of the comb, is necessary before clearance can be effected.

The slivers for this machine are arranged in balls of fours on a special "punch" box or winder. When at work the balls are placed in racks and rest upon positively driven rollers, all of which revolve with the comb circle. Eighteen of these racks form the set, and as the ball each contains consists of four ends there are thus seventy-two slivers being treated. Each sliver is taken through an endless feed-box or conductor (see sectional drawing, Fig. 97), and this is constructed with its lid hinged at the back so as to prevent backward slippage of the sliver. The box is also mounted so that when the comb is revolving its nose is free to move up and down on an inclined plane over which it runs. Immediately drawing off from the large circle has been accomplished the sliver ends are run under a press-knife (see diagram, Fig. 97), and at the same time the feed-boxes are lifted—a movement which causes the end to slide forward. The press-knife referred to may be raised or lowered in the pins, so as to vary the length of sliver drawn and control directly the amount of noil made. Once the additional length of sliver required is obtained, the end is lifted clear of the pins by fixed knives; later it is carried, by the revolution



OWS PARTS;
EATMENT OF MATERIAL.

Noble Comb

of the circle, over a plate, on which it is straightened and then laid over the large and small circles, into which it is pressed by the dabbing-brush.

The foregoing outline indicates the principle underlying the action of the Noble comb. A few matters regarding the arrangement of the machine as constructed by various makers, and as suited to the many classes of work on which it is used, must now be considered.

In the following list details are given of the comb circles, from which will be gathered, first, the system

PARTICULARS OF NOBLE COMB CIRCLES

LONG LUSTRE WOOL (40's), MEDIUM WOOL (50's), AND MERINO (64's)
LARGE CIRCLE: 42[illegible] in. diam.

No. of Rows			*Pins per In.*			*Sizes of Pins (Wire Gauge)*			*Shape of Pins (round or flat)*
40's	50's	64's	40's	50's	64's	40's	50's	64's	40's, 50's, & 64's
1	1	1	23	33	42	13 × 22	16 × 25	17 × 27	First three rows flat remainder round.
2	2	2	20	32	40	14 × 21	17 × 25	19 × 27	
3	3	3	16	28	36	16 × 20	18 × 24	20 × 26	
4	4	4	11	24	32	17	22	21 × 25	
5	5	5	9	21	30	16	21	23	
6	6	6	7	18	28	14	20	23	
7	7	7	6	17	24	13	19	22	
8	8	8	5	14	23	13	18	22	
	9	9		12	20		17	20	
	10	10		10	18		16	19	
		11			16			18	

	40's	50's	64's
Length of pins	2 in. or 2[illegible] in.	1[illegible] in.	1[illegible] in. or 1[illegible] in.
Set-over	4 in.	2[illegible] in.	1[illegible] in. or 2 in.
Width of rim	4[illegible] in.	3[illegible] in.	2[illegible] in.
Thickness of rim	9-16 in.	[illegible] in.	[illegible] in.

PARTICULARS OF NOBLE COMB CIRCLES

SMALL CIRCLE: 16 in. diam.

No. of Rows			*Pins per In.*			*Sizes of Pins (Wire Gauge)*			*Shape of Pins (round or flat)*
40's	50's	64's	40's	50's	64's	40's	50's	64's	40's, 50's, & 64's
1	1	1	25	37	46	13 × 23	17 × 26	18 × 28	First three rows flat, remainder round.
2	2	2	22	36	44	15 × 22	19 × 26	19 × 28	
3	3	3	18	32	41	16 × 20	17 × 25	20 × 27	
4	4	4	11	24	35	17	22	21 × 26	
5	5	5	9	17	30	16	19	23	
	6	6		13	25		17	22	
		7			22			21	
		8			20			20	

	40's	50's	64's
Length of Pins . . .	1¾ in. or 2 in.	1½ in.	1¼ in. or 1 3/16 in.
Set-over	¾ in.	⅝ in.	½ in.
Width of Rim	2 in.	1¾ in.	1½ in.
Thickness of Rim . . .	½ in.	7-16 in.	⅜ in.

In numbering the rows of pins, commencement is always made at the point of contact of the circles; thus in the above list the first row for the large circle is the inner row and that for the smaller circles the outer one. Much the same occurs in measuring the diameters of the circles. Regarding the type of pin, the flat or oval shape is necessary to get greater density of pins and to preserve strength of foundation. Set-over refers to the distance over which the comb is pinned. Width of rim and thickness give the size of the brass circles in which the pins are fixed.

of pinning employed, and, secondly, the modifications that obtain for standard lustre, cross-bred, and merino qualities. Additional variations necessary for intermediate qualities will readily be noted on consideration of these. It is in regard to the circles that the reason for the wide adoption of this machine by the trade is very largely to be found, for by the changing of these any class of fibre may be dealt with—a fact of considerable importance, especially to commission combers in these days of small lots. At the same time,

it is well to point out that the comb lends itself to certain qualities more satisfactorily than others, these being notably those of medium length, say 46's to 58's ; for with the longest there is too severe an action for the preserving of the maximum length of the fibre and the highest degree of lustre in the ultimate yarn, and with the shorter types the clearance is in some cases not sufficiently thorough, while in others (short "B.A." types, for instance) the minimum quantity of noil which is extracted is more than that required. Still, as a general purpose comb when turn-off is the prime consideration, it has not an equal.

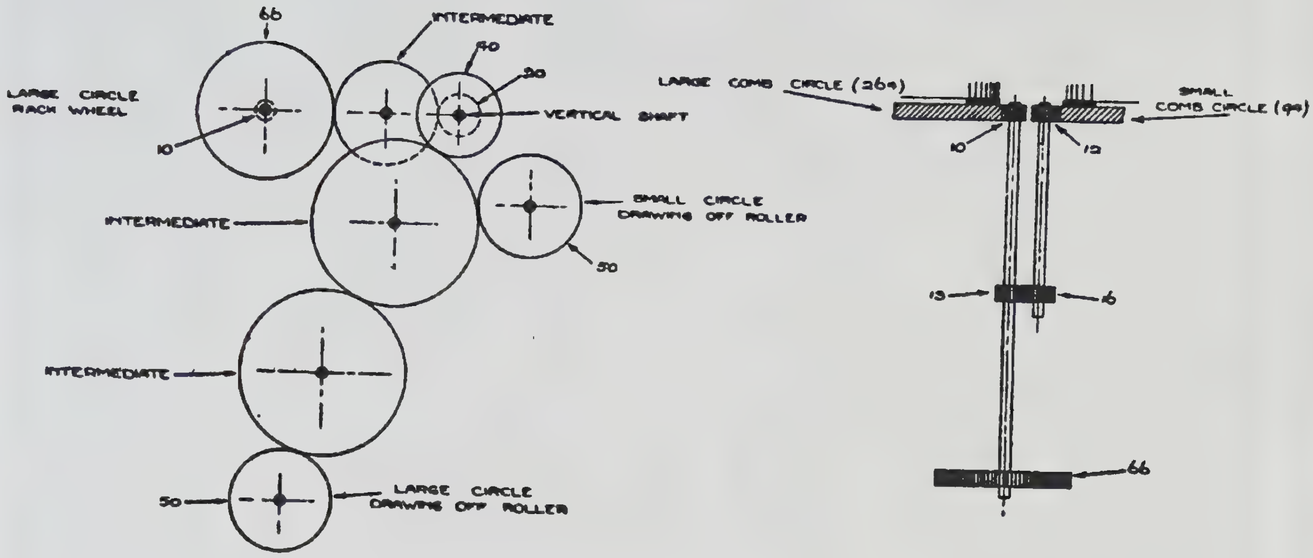
Of great importance as regards the successful running of this comb is the way in which the comb circles are mounted. When charged with wool the weight to drive is considerable, and unless they run lightly and smoothly in their bearings, driving power altogether out of proportion to the parts worked is absorbed. Much difficulty occurs here, due to the heating of the comb pins, which is necessary in order to make the fibres readily separate. Steam chests, set beneath the circles so as to almost touch, are employed for this purpose, but these have the effect of causing the circles to expand and exert undue pressure on the bearings if special attention is not paid to the form of the latter. Moreover, when this occurs fine and accurate adjustment of the circles in regard to each other and to the rollers is not possible. Formerly the circles rested on runners or discs, with additional discs horizontally set to keep them in position; these, however, did not give sufficient control. More recently ball bearings have been widely adopted with marked success. For these a semicircular groove is cut in the comb bed, and this has also its counterpart in the comb circle. Balls of $1\frac{7}{8}$ inches diameter engage the grooves for the com-

plete circumference, and being free to revolve, the comb is rolled over them with little expenditure of power, and at the same time the expansion of the circle is efficiently counteracted.

The actual driving of the comb is effected as shown in Fig. 98, through racks cut on the comb circles and wheel and shaft gearing. Usually 264 teeth are cut in the rim of the large circle and ninety-four in the two smaller. The main shaft runs at about 520 revolutions per minute, giving a large circle speed of $3\frac{1}{2}$ to 4 revolutions and a speed of the small circle just a shade in advance of this when judged by its traverse.

In this machine, as at present constructed, useful provision is made to preserve that balance in running which is essential to good work, but which may be easily lost if the floor on which the comb runs is not very good, or if the speed employed be high. Formerly four feet were the only supports of the bed-plate, and any one of these could in course of time become depressed so as to throw the part in contact out of truth with the remaining portions, in this way adversely influencing the work being done. Messrs. Prince, Smith and Son now place their comb upon a foundation-plate to which it is securely fastened; while Messrs. Taylor, Wordsworth and Co. employ a shell for the same purpose. With either of these any depression occurring at one point of the foundation affects the whole comb, and not one particular part. Perhaps the form as adopted by the last-named firm is most rigid; at the same time the under parts of the comb are not accessible as in that made by Messrs. Smith.

No part is of greater importance in the Noble machine than the dabbing motion, for it affects directly both the work going through the comb and the smoothness of movement of the machine itself. The difficulties



PLAN

ELEVATION

Fig. 98.—Diagram to show the Driving of the Noble Comb

attendant on its use arise through the conversion of circular motion into reciprocating, and the use of this at from 700 to 800 strokes a minute in the comb circle which is making lateral movement. Clearly the brush must be in and out of the circle instantaneously, but such movement cannot be obtained without jerkiness, which increases as the speed is accelerated, and which must set up vibration throughout the whole machine, particularly when the motion is attached to vertical pillars which are supported at one end only. Originally the motion consisted of crank-arm and pin. After this a cam working in a slide to which the brush was fastened was adopted, which marked a distinct advance; then more recently a second cam, working a dummy slide on the opposite stroke, has been included with yet more success. In the two last-named types the cam shaft is conical to ensure rigidity and easy running, and the working parts are enclosed in an oil chamber to enable the lubricant to be constantly applied.

The solution of the vibration difficulty has been most nearly achieved by Messrs. Taylor, Wordsworth and Co., who have taken the small circles away from the vertical pillars. In this case the dabber is mounted on a special support and may be driven from the main shaft as hitherto, but the drive is at an angle of, say, 45 degrees instead of vertical, and in a different direction on each side of the comb. By this means the strain is distributed in a way which distinctly favours steady running.

The change here noted has also brought another important advantage, which is obtained when the changing of the circles is undertaken. For this operation the cross shaft had formerly to be removed before the small circles could be lifted from their position round the vertical shafts, and this occupied, say, two to three

hours. With the new arrangement the cross shaft is by no means in the way when changing; all that is necessary is the removing of small parts—noil and press knives, etc.—and the circles may be then lifted away. Changing under these conditions may be effected with half the labour in ten minutes; it seldom requires more than half an hour.

To the same end Messrs. Prince, Smith and Messrs. Hoyle and Preston make the vertical shaft in two parts, but connect these up for working purposes. In the first case annular gearing is employed; in the latter stud and socket. In both these cases pulley blocks are necessary when changing to remove the upper part of the comb, but through there being only one piece to handle the time taken for the process is very short.

The drawing-off arrangements require a word of explanation, for it is on their accurate setting and regular working that much regarding the appearance and character of the combed top depends. They are, of course, of small size, and fluted; a leather is run round one of the pair—the press roller, which is slightly the larger—to prevent the grinding of the fibres. To preserve the life of the somewhat costly leather a traversing motion becomes necessary, and this is obtained through cams, which receive motion from the rack.

The weighting of these is vital to good work and to the condition of the leather, and needs to be uniformly applied on both bearings. For this purpose it is now customary to use worm and pinion gearing or horizontal levers, both of which are instrumental in compressing the springs to the same degree. By change of circles, as indicated, the Noble comb may be adapted to any and every class of fibre; it is largely this

flexibility which has resulted in its pre-eminence in the combing trade.

"**Tuft Comb.**"—The Lister or "Nip" comb is best described as a "tuft comb," in which one end of the tuft of fibres is combed, then the uncombed end is thrown over a revolving horizontal comb circle with the combed fibre on the outside, and finally the long fibres are separated from the short by drawing off the long fibres from the outside of the combed circle, the short fibres being left as noils in the pins, and subsequently removed by a special mechanism. It is interesting here to note that the continuous action of a revolving comb circle could only be attained by the introduction of a very ingenious mechanism causing the carrier comb to adapt itself to the curve of this circle. Thus Lord Masham had to decide either upon continuity of action obtained at the expense of ingenuity and certain complexities, or upon an intermittent action in which a straight comb feeding into a straight comb eliminated this complexity. The French comb, looked at as a "tuft" comb, should here be studied with this fact in mind.

In the Nip comb there are five main parts: a gill box without front rollers, a nip capable of being traversed, a carrying comb also made to traverse, a comb circle heated by steam chest, and drawing-off rollers. These are illustrated in Figs. 99 and 100. The slivers are fed into the gill box from cans, through rollers which pass them forward to fallers. These are densely pinned to effectively clear the fibre (*see* details, p. 250) and are of convex shape; they are also heated by a coil of gas jets to facilitate the separating of the fibre. In place of the front rollers the nip is working, and as the front faller drops to the bottom screw the nip moves up and closes over the tuft, later drawing it forward and clear-

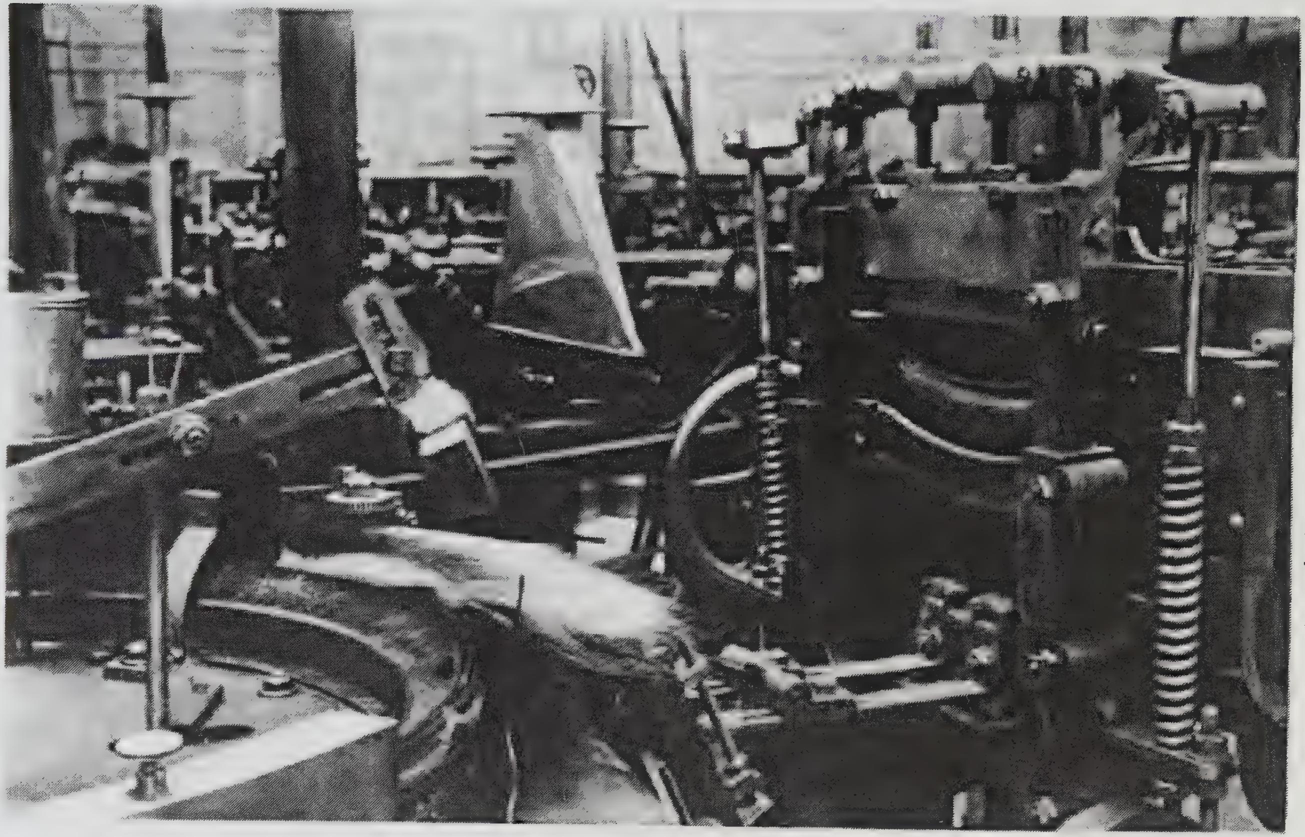


Fig. 99.—Nip Comb

(*From a photograph by W. B. Fry, Esq., Saltaire*)

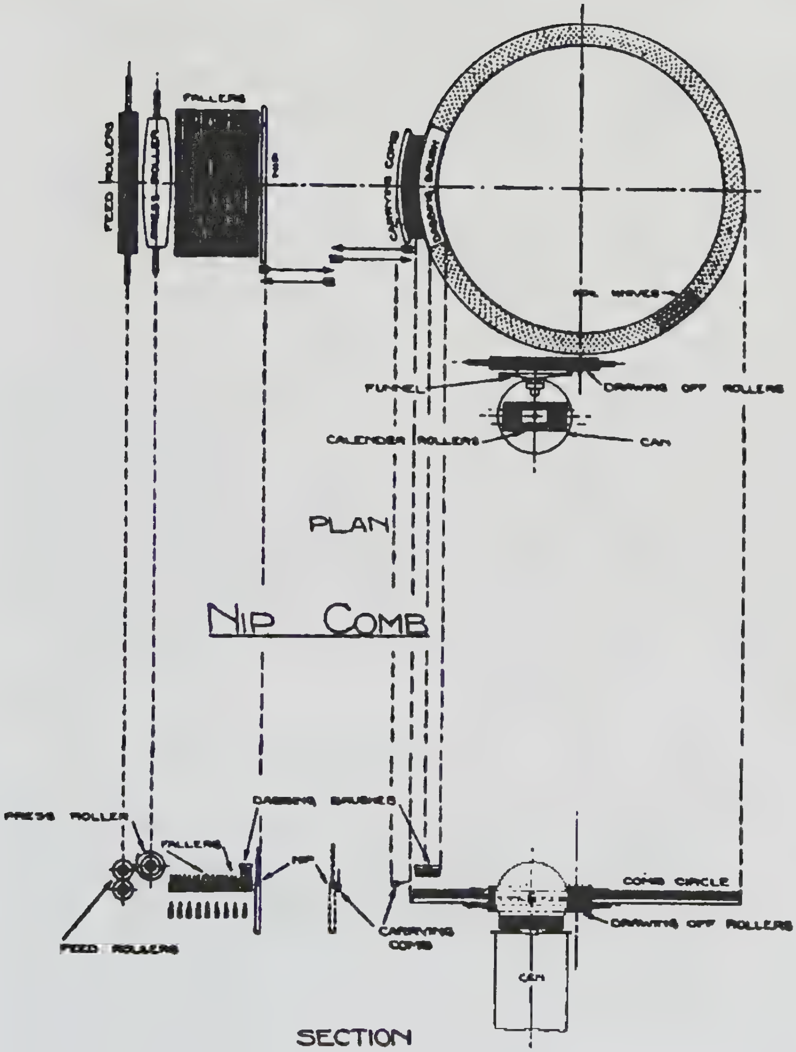


Fig. 100.—Plan and Section of Nip Comb

ing the fibres at one end in the faller pins. The nip corresponds in shape to fallers, the curve becoming necessary to prepare for a uniform overlap of the web of wool on to the comb circle. On reaching the end of its traverse the carrying comb moves up to the nip, and with its long pins takes the tuft just at this time relieved, and, moving forward, places the uncombed end on the pins of the comb circle into which it is pressed by the dabbing brush. Continued revolution of the comb circle brings the cleared end of the tuft to horizontal drawing-off rollers tangentially set where it is removed, the longer fibres first and then the shorter, the noil being left behind in the circle pins. From the drawing-off rollers the top fibres are conducted by way of a leather to revolving funnel, and thence to coiler can, false twist being employed to strengthen the end. The noil is removed by stationary knives at a further point in the circles' traverse. At various points air blasts and endless leathers assist in directing the course of the fibres.

Details of the Nip Comb.

(*a*) LONG WOOL.

Comb Circle :

Diameter, 48 inches ; width of rim, 3 inches ; thickness, $\frac{1}{2}$ inch ; set-over, $\frac{3}{4}$ inch.
Rows of pins, 5 (2 flat and 3 round) ; .length, 2 inches, but alternately 2 inches and $2\frac{1}{4}$ inches in the middle row to assist in taking wool from carrying comb.
Pins per inch, 20, 18, 16, 14 and 12 respectively.

Fallers :

Length, 20 inches ; thickness, $\frac{1}{2}$ inch ; set-over, 16 inches.
Rows of pins, 3 ; length of pins, $1\frac{5}{8}$ inches ; middle row flat, remainder round.
Pins, per inch, 18, 15 and 16 respectively.

(*b*) Mohair.

Comb Circle :

Diameter and rim as in (*a*); set-over, $\frac{5}{8}$ inch.
Rows of pins, length and shape as in (*a*), but third, fourth, and fifth alternately 2 inches and $2\frac{5}{8}$ inches.
Pins, per inch, 20, 19, 18, 14 and 14 respectively.

Fallers :

Length, thickness, and set-over as in (*a*).
Rows of pins, length, and shape as in (*a*), but with 22, 18, and 20 pins per inch respectively.

The Lister comb is specially suited for combing long wools and hairs. It is more "humane" in its treatment of the fibre, and gives as a consequence more lustre and smoothness. Through the drawing-off by horizontally-set rollers a better arrangement of the fibres for spinning results is possible than in the Noble machine. It is the comb *par excellence* for mohair, although the Noble comb is gradually restricting its sphere of influence in this country as a first comber, when convenience or turn-off is the chief consideration.

The Holden, or square-motion, comb is another "tuft comb," in which a fringe of uncombed tufts is fed on to a revolving circle; a combing head combs this exterior fringe; the combed fibres are then drawn off as "top," and the noil is subsequently removed from the pins by a special mechanism. Why this comb is specially adapted to short wools and is unsatisfactory for long wools, why the drawing-off rollers are here placed horizontally and not vertically as in the Noble comb, thereby producing a "hen-wing sliver"—these are points which should claim the most careful consideration of the would-be comber.

The Holden comb is specially suited for combing the

finest Botany wools. It yields a "top," "robbings" and "noil," of which the former is said to spin a few counts better than a Noble combed top :

Re-combing and Double Combing.—All things considered, the most economical method of introducing colour into yarns and fabrics is by "slubbing-dyeing," in other words, "top-dyeing." Thus the tops, after combing, are taken and dyed, either in hank or in extended form. This operation—or rather operations,—as there will be at least two—not only results in more broken fibre, but also in a general disturbance of the fibre arrangement, necessitating re-combing. This second combing, now often effected on the French comb, results in a beautifully clear "top," which the colour blender can work with, for the production of mixture and toned yarns, to very great advantage. Not more than 5 per cent. noil should result from this operation, and this loss should be more or less counteracted by the increase in weight given to the material through the addition of dye.

The utility of double combing for mohairs, etc., has already been referred to. It is thus evident that the comber who would be successful to-day must be prepared to consider the possibilities of the materials he handles and the capabilities of the various combs and combing operations, if he is to make the most of his opportunities.

The Finishing Processes.—When the top leaves the comb it is still in the form of a more or less irregular sliver, although the fibres may have been well averaged up and straightened. Thoroughly to level and straighten, and also to obtain the weight of sliver desired, tops —Botany or English—are usually passed through two

finishing boxes of the gill-box type, consisting of back rollers, fallers or gills, and front rollers, the first one usually delivering into a can and the last being fitted with a balling head to deliver the tops in the ball form which is invariably required by the trade, and also a knock-off motion to ensure definite lengths of slivers being balled. Of course, differences in the pinning of the fallers, drafts, etc., may be introduced as experience suggests for the particular classes of work dealt with.

The following are the approximate weights fed on to the several machines, or the doublings employed on the gill boxes, etc. :—

DRAFTS, DOUBLINGS AND WEIGHTS OF LONG WOOL AND MERINO MATERIALS

	Long Wool			Botany		
	Drafts	*Doublings*	*Weights*	*Drafts*	*Doublings*	*Weights*
Washing . .						
Drying . .						
Preparing .		10 (last box)	3oz. per 5 yds.			
Carding . .						
Backwashing	8	10			16	
Straightening	7·8	9 & 9			4 & 4	
Combing . .	—	72			72	
Finishing . .	6	20 & 4	6oz. per 5 yds.		16 & 2	3 to 3½ oz. per 5 yds.

Sets of Combing Machinery.—As the processes from the raw wool up to the combed top are definitely organised as one trade, spoken of as the combing industry, it will here be desirable to study sets of machinery designed to comb long, medium, and short wools to the greatest advantage.

RANGE OF BRADFORD TOPS:

No.	Quality No.	Length (in inches) Extremes Long	Length (in inches) Extremes Short	Length (in inches) Mean	Lustre or Colour	Handle	Soundness	Fineness (Average)
1	28's	15	5	10	Greyish non-lustrous	Harsh	Weak and brittle (Kempy)	1-200 in. to 1-400 in.
2	32's	13½	6	9	Fairly lustrous	Fairly harsh	Weak	1-400 in.
3	36's	12½	8½	10	Fairly lustrous	Fairly soft	Fairly sound	1-500 in.
4	40's (Preparer)	12	8½	10	Very lustrous	Soft	Sound	1-600 in.
4a	40's (Carder)	9½	5	7½	Lustrous	Soft	Sound	1-600 in.
5	44's (Preparer)	11	8½	10½	Very lustrous	Soft	Very sound	1-650 in.
6	46's	9	4½	7½	Fairly lustrous	Harsh	Sound	1-700 in.
7	50's	7½	3½	6	Lustrous	Fairly harsh	Sound	1-750 in.
8	56's	6½	2½	5½	Yellowish in colour	Fairly soft	Sound	1-900 in.
9	58's	6	3	5	Fairly white in colour	Fairly soft	Sound	1-950 in.
10	60's (Warp Qual.)	5½	2½	3½	Fairly white in colour	Soft	Sound	1-1000 in.
11	64's	5	2½	3½	White in colour	Soft	Sound	1-1200 in.
12	70's	4¾	2½	3½	White in colour	Very soft	Sound	1-1200 in. to 1-1400 in.
13	80's	4½	3	3½	Very white	Very, very soft	Very sound	1-1400in. to 1-1700 in.
14	90's	4½	3	4	Very white	Very, very soft	Very sound	1-1700in. to 1-2200 in.

DETAILS OF QUALITIES

Waviness	*Uniformity*	*Probable Breed or Breeds*	*Count of Yarn Limit*	*Uses*	*Market Value Apr., 1909 (Pence)*	
Straight	Irregular	Low Scotch and Low English	16's	Carpets, low hosieries, etc.	9	
Straight	Irregular	Fine Scotch Medium English Low Crossbred	24's	Low lustres and serges	10½	
Straight	Fairly uniform	Fine Scotch Fine English Medium Crossbred	28's	As No. 2	11½	
No waviness clearly defined	Uniform	Best Scotch Medium Crossbred Fine English	36's	Best lustres, dress serges, and medium suitings	12½	Standard for Comparison — 40's
Slightly wavy	Uniform	As No. 4, but slightly shorter types	32's	Lustres, dress serges, medium suitings	11½	
No clear waviness	Very uniform	Best English Lustre and Colonial Crossbred Wool	40's	Best lustres—dresses and linings	13½	
4 waves per inch	Uniform	Shorter British Wools and Medium Crossbreds	40's	Fine serges, hosieries, and Medium crossbreds	15½	
10 waves per inch	Fairly uniform	Down Wools Fine Crossbreds Low Botanies	44's/46's	Fine serges, medium coatings, and hosieries	17	
14 waves per inch	Fairly uniform	Finest Down Wools Crossbreds and Low Merinoes	48's	Medium coatings and dress goods	22	
20 waves per inch	Fairly uniform	Fine Crossbreds and Strong Merinoes	50's	Cheap fine worsted coatings and dress goods	23½	Standard for Comparison — 60's
24 waves per inch	Fairly uniform	Finest Crossbreds Merino Skin & Fleece wools	48's/5's	Fine coatings, dress goods, hosieries, etc.	25	
28 waves per inch	Uniform	Strong Merinoes Fleece, and Skin Wools	56's	Fine coatings, dress goods, hosieries, etc.	26	
32 waves per inch	Uniform	Fine Merino (classed fleece)	80's	Very fine coattings and dress goods	28½	
36 waves per inch	Very uniform	Fine Merino (sorted fleece)	100's	As No. 12	30	
36 waves per inch	Very, very uniform	Fine Merino (sorted fleece)	150's	As No. 12	34	

Long wool set for English or Cross-bred, 32's to 44's quality:

Washing.—Three swing-rake bowls.
Drying.—One mechanical dryer or three hand machines.
Preparing.—Four sets of first and second sheeter and third and fourth can boxes.
Backwashing.—Three eight-cylinder machines, each with gill box in position of fifth preparer.
Opening and Straightening.—Three pairs of can and baller levelling boxes.
Combing.—Eight Noble combs, also punch box.
Finishing.—Five pairs of can and baller finishing boxes.

Such a set as the foregoing would turn off 4,800 lb. of tops per day of ten hours.

Merino wool set, 60's average qualities:

Washing.—Two sets of four bowls, swing harrow type.
Carding.—Twenty-four carders.
Backwashing.—Four nine-cylinder backwashers, each with gill box.
Opening and Straightening.—Ten pairs can and baller levelling boxes.
Combing.—Twenty Noble combs, with three punch boxes.*
Finishing.—Fifteen pairs can and baller finishing boxes.

This set would probably produce 4,500 lb. of tops per day of ten hours.

A most careful study of the possibilities of each machine, of the various relationships obtaining, and of the *balance* of complete sets of machinery, should here be made.

Range of Bradford Tops.—In the list on pp. 254 and 255 an attempt is made to standardise tops. In conjunction with the frontispiece it at least gives a good idea of what is possible in this direction.

* Should square motion combs be used instead of the Noble machine, two or three fewer might suffice. In such an event the opening and straightening operation might probably be omitted. Were the French comb substituted about thirty machines would be necessary.

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